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AN ASSESSMENT OF COMPUTATIONAL PROCEDURES  
TO DETERMINE REQUIREMENTS OF CRITICAL AND  
STRATEGIC MATERIALS

Robert W. Gilmer  
Paul McCoy

August 1977

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**AN ASSESSMENT OF COMPUTATIONAL PROCEDURES  
TO DETERMINE REQUIREMENTS OF CRITICAL AND  
STRATEGIC MATERIALS**

Robert W. Gilmer  
Paul McCoy

August 1977



**INSTITUTE FOR DEFENSE ANALYSES  
PROGRAM ANALYSIS DIVISION  
400 Army-Navy Drive, Arlington, Virginia 22202**

Task Order T-122

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## Chapter I

### ASSESSING THE ADEQUACY AND ACCURACY OF ESTIMATES OF STOCKPILE REQUIREMENTS

The objective of stockpiling critical and strategic materials is to prevent a dangerous and costly dependence upon foreign producers by the United States in a time of national emergency. The U.S. government held inventories of over \$7 billion worth of materials in 1975 under the authority of the Strategic and Critical Materials Stockpiling Act.<sup>1</sup> The stockpiling function has been carried out by the Federal Preparedness Agency<sup>2</sup> (FPA) since 1973, when stockpiling activities were delegated to the General Services Administration.

The quantity of materials held by FPA represents the shortfall between the estimated requirements of the material needed to support a large-scale mobilization and estimates of what could be supplied in emergency conditions. To determine the quantity of materials needed, an econometric model is employed to project material needs under wartime conditions. Stockpiles are to be maintained for the first year of a conventional war fought simultaneously in Europe and Asia. The size of the mobilization is geared to troop strength estimates; the need for essential military and military-supporting material follow the troop-strength estimates closely. Supply estimates reflect known sources in the United States and foreign countries, and judgments concerning the accessibility of these sources

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<sup>1</sup>At 50 U.S.C. 98 et seq. Reprinted in Federal Preparedness Agency, "Stockpiling Report to the Congress," (Jan-Je, 1975), pp. 28-32.

<sup>2</sup>Formerly the Office of Preparedness, formerly the Office of Emergency Preparedness.

in wartime. Allowance is made for foreign capacities and the risk of transporting materials in wartime.

The difference between estimated needs for a material and its availability is the stockpile objective. The objective is zero if the difference between mobilization needs and supply is zero or negative; the objective is positive if requirements exceed supply. Current objectives, present inventory levels, excess quantities of materials, and the quantities which Congress has authorized for disposal are published periodically by FPA.<sup>1</sup> Changes in objectives occur with new requirements or supply data, and materials may be added to or deleted from the stockpile as new data enter the calculation of objectives. New materials are considered for stockpiling by surveying relevant government and private sources, and upon the recommendation of the National Materials Advisory Board.

The purpose of this report is to assess the adequacy and accuracy of the computational procedures used to determine the requirements for critical and strategic materials during a mobilization. Basically, this assessment will accept the scenario of conventional war and the other geopolitical factors that enter the model as data. The objective will be to assess the adequacy of the economic assumptions employed in building the model, and the accuracy of the resulting projections. The narrow focus on the implementation of the model allows us to side-step a number of troublesome policy questions, and to consider the technical details of economic model-building apart from them.

#### A. AN OVERVIEW OF THE MODEL

Figure 1 outlines the computational procedures used by FPA to compute stockpile requirements. Given a list of candidate

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<sup>1</sup>"Stockpiling Report to the Congress," *op. cit.*

materials, the requirements are projected using the procedures outlined on the left side of the page; the availability of materials is computed using those on the right. The difference between these estimates is the stockpile objective shown at the bottom of the figure.

The availability of materials will be of little concern in this report. The estimates depend on domestic and foreign production capacity, and these are adjusted for the effects of war. Adjustments are made to these estimates for the willingness of the political regime controlling the source of supply to trade with the U.S. in time of war, and for losses which may be inflicted upon supply lines by the war itself. These assumptions may be quite controversial in many instances and the value of the assumptions employed may be debatable, but they are generally a straightforward set of calculations. There is little chance of inadvertently entering assumptions or data which are not easily interpreted by policy-makers or others using the calculations.

The calculation of material requirements is not accomplished in such a lucid manner; the result is more of a black-box with inputs and outputs having no simple relationship. The assumptions employed are often difficult to adequately judge out of context of the system as a whole, and the system is large and not amenable to easy interpretations. A lack of documentation and an inability by FPA to convey the adequacy of the technical details of this model have led to some misgivings concerning its usefulness. Accordingly, our assessment has centered on these aspects.

The requirements are generated by initially dividing the total output of the U.S. into its constituent uses--consumption, investment, government spending, and net exports. The uses of income during a mobilization are projected with the



use of a large macroeconomic model and a substantial number of policy judgments. Although the statistical relationships of the model are used to forecast some variables, policy judgments finally determine the uses of income: enforced austerity reduces consumption, housing construction is postponed to reduce some categories of investment, new defense needs push government spending up, and foreign markets are affected by the war. Total income is forecast by the model, but policy assumptions determine its composition.

The uses of income are transformed into final demands imposing requirements on 86 industries. The demands on each industry--aircraft, household appliances, motor vehicles, etc.--imposed by each use of income are computed using "bridge" tables; which are taken from published sources or constructed by FPA. Given final demands, the direct and indirect requirements of all 86 sectors are computed using an input-output model. The total output of each industry is that imposed by each use of income plus intermediate requirements.

Materials (the computation of the requirements for materials is the purpose of the model) enter the calculations only after the total requirements of each industry are computed. Every material has its use determined in each of the 86 sectors, and the quantity of every material used per dollar of total output by the (i)th industry is computed. The utilization of a material by the (i)th industry,  $C_i$ , is defined

$$C_i = \frac{\text{quantity of material}}{\text{dollars of output}},$$

and is called the consumption ratio. If  $Q_i$  is the output required of industry (i) in a mobilization, the use of the material by this industry is assumed to be

$$M_i = C_i Q_i.$$

Total use of the material by all  $i = 1, \dots, n$  industries would be

$$M = \sum_{(i)}^n M_i = \sum_{(i)}^n C_i Q_i.$$

The consumption ratios may be adjusted for trends in technology within each industry, or for substitution in some cases.

The requirements for each material are compared to the supply estimates. If requirements exceed availability, a positive objective is established.

## B. ASSESSING THE ADEQUACY OF THE MODEL

If the adequacy of the model is to be addressed in a meaningful way, then some *a priori* criteria need to be established against which the model can be judged. A model is an abstraction, of course, and it is unlikely that any computable model can be constructed that handles all aspects of a large-scale mobilization very well. Indeed, as we will see, the FPA model handles some key aspects quite well, but at the expense of some inaccuracy being imposed in other areas. In this section the economic problems imposed by a mobilization will be considered in simple, abstract terms to sort out a set of criteria to assess the adequacy of the model. The relevant questions posed by the mobilization problem come quickly to the forefront once this is done.

### 1. The Short-Run Impact of Mobilization

During the first few months of a mobilization, the capacity of most producing industries is likely to be fixed. It may be possible to expand output substantially beyond current production levels by using two or three shifts, some older or

less suitable plants, or other extraordinary (and increasingly expensive) means, but a real upper bound on output finally exists. This short-run problem will be considered first, with the longer-run problems of capacity expansion considered later.

a. Expanded Military Requirements

As an example, consider the requirements for truck production in a mobilization. In Figure 2 suppose that the curve  $S$  is the cost per unit (the vertical axis) as truck production increases (on the horizontal axis). The curve is relatively flat over a wide range of production levels, but it begins to rise sharply as production approaches the capacity output,  $T_0$ . This increasing cost results from the use of multiple shifts, less highly skilled labor, older or less suitable tooling, etc., all of which forces costs to higher levels. At  $T_0$  no more production is possible at any reasonable cost and this level reflects the capacity constraint in the short-run.

Suppose  $R_p$  is schedule reflecting the number of trucks that would be purchased at various prices during peacetime. This reflects both the civilian and military need for trucks and assumes that more trucks are purchased at lower prices than at higher prices. The price per truck covers the production costs at  $C_p$ , and  $T_p$  units are purchased at a price of  $C_p$  dollars each. This is an equilibrium, as higher prices discourage consumer purchases but encourages production. The resulting excess output forces prices down as producers are unable to sell their total truck output. Lower prices have the opposite effect of creating a demand for trucks, but not adequately covering production costs.

A mobilization expands the requirements for trucks. A high proportion of the truck requirements will be associated with urgent, new military needs. At every price level more

trucks would be purchased than in peacetime, and the schedule of requirements shifts sharply to the right to  $R_W$ . The short-run effects of this expansion of truck requirements is to force production costs and the price sharply upward to  $C_W$  as output rises to  $T_W$  units.

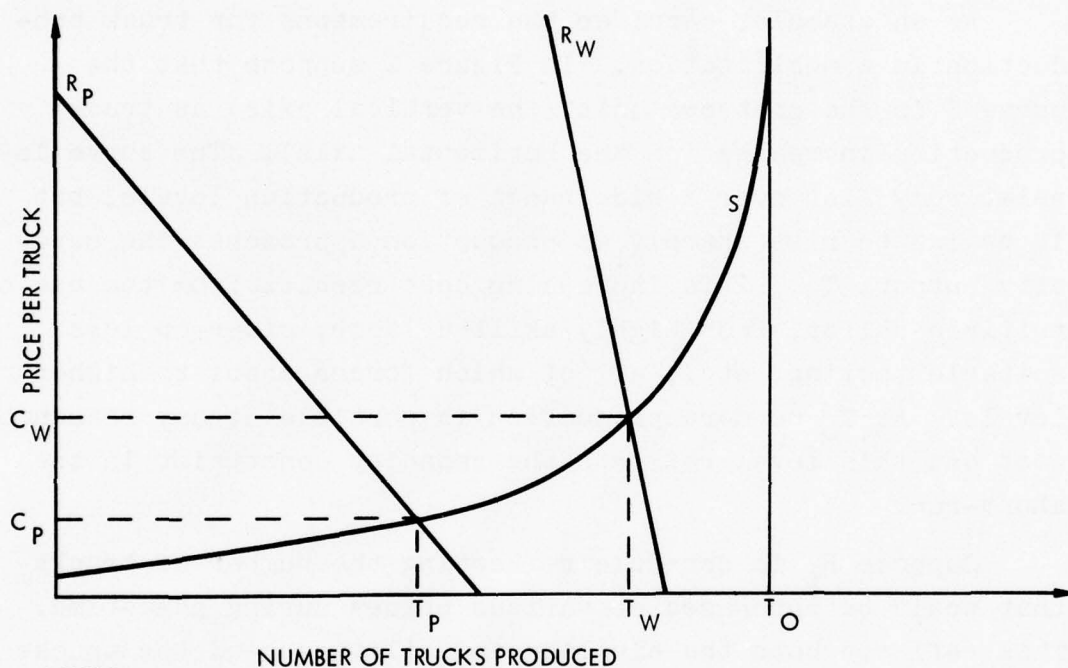


Figure 2. TRUCK PRODUCTION IN PEACETIME AND UNDER MOBILIZATION

b. Stockpiling and Intermediate Inputs

The shift along the supply or cost curve  $S$  from  $T_p$  to  $T_w$  assumes that the same technology is used at both production levels; i.e., the same raw materials and other inputs are available as in peacetime. Since the availability of inputs is the heart of the stockpiling problem, this assumption bears close scrutiny. Problems of assuring the supply of trucks may

arise from three sources: (1) a cut-off of needed raw materials such as cobalt, beryl ore, rutile, etc.; (2) an inability to obtain processed or value-added inputs such as iron or steel castings, forgings, electronic components, etc.; or (3) problems in processing associated with scheduling difficulties or resulting from improper managerial practices.

The stockpiling issue is, of course, most immediately concerned with raw materials and the new requirements for them as the output of military end-items expands. However, it must be responsive to the production of value-added items as well. A truck factory buys very few raw materials. It buys numerous partially processed inputs and assembles them, e.g., engine blocks (castings), ignitions (assembled electronic equipment), wheels (forgings), tires (synthetic rubber), some textiles and plastics and a myriad of other parts. The raw materials have to be guaranteed not just for the truck industry, but for the hundreds of intermediate production processes that contribute processed or assembled inputs to the trucking industry as well. Certainly a narrow focus on military end items is inadequate, and the consideration of raw material needs for the entire industrial base--including both military end items *and* the intermediate production contributing value-added inputs--is a necessity. An important criterion of a "good" model is that it be responsive to the needs of the entire range of production processes, and that it consider more than the needs of those industries finally shipping defense-related goods.

#### c. Effects of Substitution

The supply or cost curve S assumes a given technology and that certain materials and processes are available; these materials and processes are used because they assure minimum production costs during peacetime. Implicit in the cost

structure of curve S may be a copper fitting for the truck, which is used because it is pennies cheaper than a perfectly effective plastic substitute. The nonavailability of copper does not imply that trucks won't be produced or that the shortage of copper will stop production. Instead we find production on a slightly higher cost curve, such as S\* in Figure 3 (above), reflecting the new "technology" of a plastic fitting. All producing trucks, although at a slightly higher unit cost,  $C_w^*$ . It is not clear that we should want to stockpile large amounts of copper to save a few pennies on each truck, so the role of substitute materials and processes will affect our determination of raw material needs.

Studies of the adaptability of national economies to dislocations of basic materials suggest that substitute processes or materials are almost always available, although not necessarily as cheaply as the example above would imply. A study of the efforts to blockade British food supplies in three wars suggests the extent to which substitution may be made to work when necessity dictates it. By plowing pasture land, rationing, changing crop patterns, not feeding meat animals but having people consume calories directly, and altering many traditional patterns of agriculture, the British never really suffered food shortages in these wars.<sup>1</sup> A similar examination of the effects of the Combined Bomber Offensive over Germany in World War II illustrates the same possibilities in the industrial sector. Germany substituted synthetic gasoline produced from coal as it was cut-off from oil fields; military equipment

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<sup>1</sup>The Napoleonic War, World War I, and World War II are considered at length with exactly the point being made here in mind. Mancur Olson, *The Economics of the Wartime Shortage* (Durham, N.C.: Duke University Press, 1963).

<sup>2</sup>Mancur Olson "The Economic of Target Selection for the Combined Bomber Offensive," *Royal United Service Institution Journal*, CVII (Nov. 1962), 308-14.

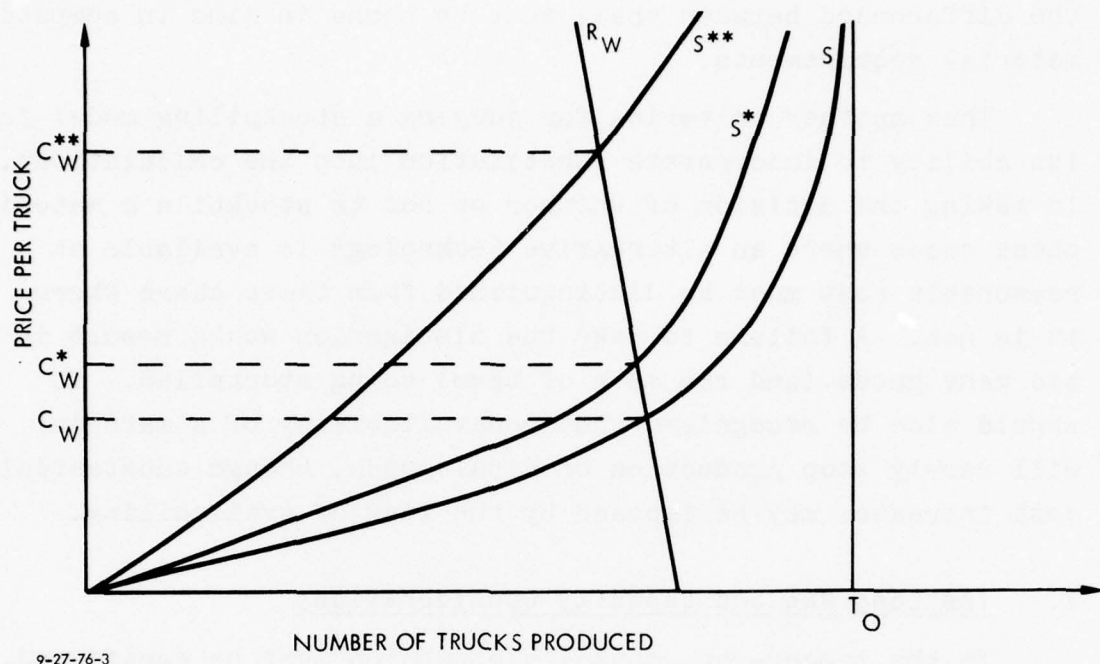


Figure 3. TRUCK PRODUCTION AND MATERIAL SUBSTITUTION

was produced without many important alloys available but with little technical performance loss; and efforts by the Allies to bomb key industries such as ball-bearing plants simply induced the wide-spread design of other kinds of rollers and anti-friction devices into the German equipment. This is not to imply that a stockpile is unnecessary because of substitutes. Enormous costs were imposed upon Britain and Germany by the measures taken against them. In Figure 3, if the alternative technology for truck production is  $S^{**}$  due to a lack of a critical material such as chromium for stainless steel, it is probably wise to stockpile it; otherwise tremendous costs could be inflicted upon the economy during a mobilization, and the cost of carrying on the war would be greatly increased. But the copper fitting and chromium examples, and

the differences between them, must be borne in mind in computing material requirements.

Thus another criterion for judging a stockpiling model is its ability to incorporate substitution into the calculations. In making the decision of whether or not to stockpile a material, those cases where an alternative technology is available at a reasonable cost must be distinguished from those cases where it is not. A failure to make the distinction would result in too many goods (and too much of them) being stockpiled. It should also be recognized that nonavailability of a material will rarely stop production of vital goods, though substantial cost increases may be imposed by the lack of availability.

## 2. The Long-Run and Capacity Considerations

In the longer-run, capacity expansion must be considered. The FPA scenario considers a three-year war and, given the exigencies of war, few industries could not be expanded in this time period. Consideration of capacity expansion poses at least two important problems. What new material requirements are imposed by the need for extensive new construction projects? If we impose a desired set of military production, is there capacity available in defense-oriented and intermediate industries to handle the expanded output requirements, even if the materials are available?

(1) Expanding Capacity. A war of three years will undoubtedly impose substantial requirements for new construction. To some extent civilian construction such as housing can be postponed but new construction to support the war effort is inevitable and an overall expansion of construction will occur. Such construction is known to intensively use basic materials and the model should consider these requirements explicitly. The problem is considered in more detail in the next chapter.

(2) Available Capacity. It is fruitless to compute material needs to support a mobilization at a particular level if there are bottlenecks in fundamental processing industries. Serious bottlenecks disrupting deliveries of military hardware may occur not only in defense-oriented industries, but in intermediate industries as well. No matter how many truck assembly plants we build, it may not be possible to expand the production of trucks until there are enough foundries, forges, and other intermediate producers to provide the parts to be assembled. Again the likely result of a failure to consider this problem would be too many materials stockpiled and too much of each one. The materials supply could not be used if the capacity were not there.

### 3. Criteria to Judge the Model

The preceeding analysis suggests several important criteria by which a model of the stockpiling process should be judged.

- The mode should be responsive to a major expansion of defense needs and to extensive new production requirements. It must consider not only direct defense needs, but the industrial capacity needed to support the defense effort.
- In computing the requirements for materials, allowance should be made for major efforts to expand capacity in defense-oriented industries.
- The model should handle the substitution problem reasonably well. A material should be stockpiled only if substantial cost or performance losses are imposed by inadequate quantities of material.
- Potential short-run constraints on output posed by capacity shortages in key industries should be considered to avoid overstocking. Bottlenecks may limit production even if materials are made available.

In addition to these broad criteria, other less general standards should be imposed. How well and how often is the model updated? Are the best available data used? Are the

data good enough to assure credibility of the results. Numerous other details relating to the implementation of the model will be examined.

### C. ASSESSING THE ACCURACY OF THE MODEL

Any large-scale computational scheme is an approximation and as such will be subject to some criticism. An important test of such a system is its predictive accuracy and its response to changing conditions. Surprisingly little effort has been made to verify or test the predictive ability of the model.

A major part of our effort was invested in some basic tests. The accuracy of the projections do little to establish the intellectual content of the model or its credibility as a description of the real world,<sup>1</sup> but it is important in establishing the usefulness of the model. Certainly assessing the accuracy of the model is crucial in interpreting any of its results. We have used three basic means of attempting to establish this credibility: "backcasting" the peacetime requirements for a series of materials; comparing the material needs projected by the model for wartime to another large-scale model operating on somewhat different principles; and an attempt to derive some more direct estimates of material usage. Together these tests provide a better feel for the accuracy of the projections than was available before. Chapter IV will describe these tests in detail.

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<sup>1</sup>This was the purpose of the procedures outlined in the preceding section.

## Chapter II

### MOBILIZATION AND THE USES OF INCOME

The initial step in determining the economic effects of a large-scale mobilization is to determine its effects on income flows. The FPA model projects the flows of income using a macroeconomic model and a series of policy assumptions concerning the components of income. The definition of income used is that formulated from the "uses side" of the income stream: consumption, investment, government spending, and net exports. The dollar value of these categories exhaust gross national product (GNP) which is a measure of total income. GNP and its constituent parts are listed in Table 1, along with the values of these income streams in 1975.

In this chapter, the macroeconomic model and the policy assumptions used in making the projections of income flows will be examined in detail. This review provides a good opportunity to critically survey the set of assumptions that guide the mobilization, and it is this basic set of assumptions or scenarios that the computational model must reflect. This chapter is a necessary preface to a survey and summary of these computational methods.

#### A. THE USE OF THE MACROECONOMIC MODEL

The effects of the mobilization--expanded government spending, changing employment patterns, etc.--are used as data

Table 1. COMPONENTS OF GNP IN 1975  
(BILLIONS OF 1972 DOLLARS)

	1975 Values
GROSS NATIONAL PRODUCT	1,186.4
PERSONAL CONSUMPTION	766.6
Durable Goods	109.3
Nondurables	306.9
Services	350.4
GROSS PRIVATE DOMESTIC INVESTMENT	149.0
Equipment	75.3
Residential Structures	36.6
Nonresidential Structures	37.1
Change in Business Inventories	-10.1
GOVERNMENT PURCHASES OF GOODS AND SERVICES	257.4
Federal	94.2
Defense	72.1
Nondefense	22.1
State and Local	163.2
NET EXPORTS	16.6
Exports	97.6
Imports	81.0

Source: *Economic Report of the President, 1976*

in a large macroeconomic policy model of the U.S.<sup>1</sup> Known as the MCL-Thurow Model, it provides a set of projections of consumption, investment, government spending, and export needs. Table 2 shows the Thurow peacetime projections for 1977 and 1978 in the first two columns, respectively. The

<sup>1</sup> Patricia R. Devine, *The MCL Thurow Model*, TR-93, Office of Preparedness (Feb. 1974); Lester Thurow, "A Fiscal Policy Model of the United States," *Survey of Current Business*, 49 (June 1969), 45-64.

Table 2. PROJECTIONS OF INCOME UNDER A MOBILIZATION BY THE  
MCL-THUROW MODEL BEFORE POLICY ADJUSTMENTS  
(Billion \$ 1972)

USES OF INCOME	1977 PEACETIME	1978 PEACETIME	1978 MOBILIZATION
GROSS NATIONAL PRODUCT	1305.1	1338.3	1564.3
PERSONAL CONSUMPTION	824.2	845.6	879.6
Durables	137.5	141.7	163.4
Nondurables	327.6	334.0	358.7
Services	359.4	370.7	357.7
GROSS PRIVATE DOMESTIC INVESTMENT	196.3	203.3	207.1
Fixed Investment	178.0	194.2	146.7
Structures	33.9	35.7	42.0
Producer's Durable Equipment	78.6	87.2	104.7
Residential	30.8	31.4	30.8
Change in Business Inventory	16.3	9.1	30.6
GOVERNMENT PURCHASES <sup>a</sup>			
Federal	59.2	59.7	90.5
State and Local	91.9	94.6	92.6
NET EXPORTS	7.9	6.7	13.1
<sup>a</sup> Goods only, compensation is not shown.			

wartime projections for 1978, assuming 1978 is the first year of a mobilization with a build-up in forces to five million men, are shown in the third column. These basic data will be altered later by a series of policy adjustments that affect the *composition* and sometimes the actual size of some major flows. The composition of investment spending, for example, may be altered between producers durable equipment and residential structures, but the total investment flow remains fixed.

The MCL-Thurrow Model is a technically competent policy model of the United States. To assess its predictive value, the prediction errors were compared to two naive predictive

models. Model  $R_1$  assumed that the best estimate of next year's income (or consumption, investment, etc.) would be this year's value; i.e., that the value would not change.

$$R_1: \quad XACT(t) = XEST(t+1) \quad .$$

Model  $R_2$  assumed that the change in this year's value was the same as the change in last year's value.

$$R_2: \quad XEST(t+1) = XACT(t) + [XACT(t) - XACT(t+1)] \quad .$$

To test whether the macroeconomic model predicted better than the two naive models, errors in the three models were computed for the period 1950-72. Table 3 shows the ratio of the errors in Thurow to those of  $R_1$  and  $R_2$ . Where these ratios are less than one, the macroeconomic model does better than the naive forecasts. The Thurow Model was superior in every major category except nondurable consumption; it fell down on nondurables and some smaller subcategories thereof.

The model performs reasonably well on historical data. Any misgivings about the value of the income projections are probably better directed at the policy assumptions concerning the changes in income flows. This concern should be expressed in two ways: (1) How should income streams be altered? (2) Is there any feedback from these changes to the initial macroeconomic projections? The first of these questions will be examined at some length in this chapter; the answer to the second has been assumed to be a simple "no" by FPA. It is easy to have misgivings concerning these rather sweeping changes--a shift from durable goods to nondurable goods by 25 to 75 percent, or from residential investment to producers durable equipment by 25 to 75 percent--and with a conclusion that they do not feedback on the initial estimates of income. On the other hand, the broad, sweeping nature of these

Table 3. COMPARISON OF THUROW MODEL TO TWO NAIVE ESTIMATES

	Average % Absolute Error-- Thurrow	Ratio of Thurrow Error to $R_1$	Ratio of Thurrow Error to $R_2$
GROSS NATIONAL PRODUCT	2.04	0.535	0.659
PERSONAL CONSUMPTION EXPENDITURES	2.53	0.687	1.222
Durables	4.61	0.619	0.500
Nondurables	3.61	1.221	2.473
Food	3.16	1.371	2.356
Clothing	9.41	2.902	2.871
Gas & Oil	2.09	0.386	0.784
Other Nondurables	4.45	1.212	2.720
GROSS PRIVATE DOMESTIC INVESTMENT	2.73	0.348	0.237
TOTAL GOVERNMENT SPENDING	0.00	0.108	0.136
<p>Note: Based on data from 1950-72. Errors are computed from run C-I using actual lagged endogenous variable values from Patricia R. Devine, <i>The MCL-Thurrow Model--Supplement</i>, GSA/OP/MCL, TR-96 (February 1975). <math>R_1</math> assumes <math>XEST(t+1) = XACT(t)</math>; <math>R_2</math> assumes <math>XEST(t+1) = XACT(t) + XACT(t) - XACT(t-1)</math>.</p>			

assumptions--almost certainly an order of magnitude at best--may make the question of such precision a moot point.

The next section will review the policy assumptions that must be made to implement the model. It becomes clear that the contingency for which FPA is planning is only vaguely understood. This uncertainty cannot be remedied to any great extent, and it is necessarily an integral part of the problem we are faced with here. The range and magnitude of alternatives considered by FPA make it clear that there are a broad range of acceptable planning data which fit the uncertainties

involved in planning for a future mobilization. The scenario employed by FPA guidance is continually reviewed and updated and, although these data have a firm administrative basis by virtue of being handed down from the National Security Council, the data always bear an uncertain relationship to any future emergency. The final section of this chapter looks at the sensitivity of the material needs projected by the model, and the effect of these assumptions on the accuracy of the projections.

#### B. POLICY ASSUMPTIONS AND THEIR EFFECT ON INCOME

In reviewing the proposed FPA guidance for a mobilization, it becomes clear that these scenarios have drawn from historical precedent in World War II and the Korean conflict, and these analogies have (in most cases) served as patterns for the assumptions made. We found it useful--and it will serve as the pattern for much of this section--to place the assumptions made by the scenarios explicitly against the patterns of earlier wars. This provides a useful gauge of the magnitude and direction of some of the parameters used. It is not necessarily to be inferred that World War II or the Korean conflict are actual patterns for the scenarios in any way, but the comparison does serve as a beginning point for asking how modern war has been assumed to be different.

The guidance assumes the war to be strictly conventional, lasting three years, and fought in Western Europe and/or land Asia. Access to the Persian Gulf and Mediterranean ports is assumed to be denied. Two alternative levels of effort are envisioned: (1) a full mobilization with manpower expanding from 2 to 15 million men over the course of the war; and (2) a limited mobilization effort as the Reserves and National Guard have 5 million men on active duty, but Selective Service is not used.

World War II began as a limited mobilization with the outbreak of war in Europe. Readiness was increased by expanding the Armed Services from 500,000 men to nearly two million in 1940; the number of civilians employed for defense purposes doubled that same year. Through the Lend-Lease Program, the industrial base--which had a great deal of slack in it when the war broke out in Europe--was redirecting its production efforts toward war materiel. With the American entry into the war in late 1941, the Armed Services began an expansion that peaked with 12 million men in uniform by 1945. The number of civilians employed for defense purposes rose from 500,000 to 2 million during the same period. The Defense Budget shot up from \$1.5 billion in 1940 to \$74.6 billion in 1944, accounting for nearly half of the Gross National Product. The mobilization effort had probably not reached either a military or industrial peak by the end of the war.

Limited or partial mobilization assumes sustained effort at levels well below the maximum rate possible. Both the limited mobilization before World War II and the Korean conflict represented a two-fold decision: (1) to substantially rearm the military forces and expand combat capability on a limited basis; and (2) to provide an industrial mobilization base capable of being accelerated to higher levels in the event of an escalated war. The first of these requires an expansion of munitions and equipment production; the second requires systematic expansion of production lines needed to produce materiel. The 1950 mobilization in Korea saw the size of the Armed Forces more than double from 1.5 million to 3.6 million men on active duty; the number of Defense Department civilians rise from 750,000 to 1.3 million; and the DoD budget rise from \$12.1 billion to \$38.9 billion.

There are great uncertainties in any effort to foresee stockpile requirements. Accordingly, a range of assumptions

have been made by the scenarios to reflect the possibility of greater or lesser reliance on the stockpile (see Table 4). Case 1 has been designated as a set of assumptions which place substantial demands on the stockpile; Case 2 places lesser demands for materials on the stockpile. Case 1 is termed "less risky" and Case 2 "riskier." Assumptions throughout Case 1 are biased toward creating heavier material requirements and a larger stockpile; Case 2 is just as deliberately biased toward assumptions requiring a smaller stockpile.

A third class is also assumed which is supposed to lead to a "balanced" stockpile. Requirements are broken down into those necessary to support the military effort (DoD), essential civilian consumption (EC), and other forms of consumption (OC). Stockpiling occurs so that DoD needs are quite safe, the essential civilian needs are safer, and other consumption is generally at risk. The descriptions of the various assumptions made in the scenario will generally involve two-way tables, such as Table 4, so the assumption for each risk/mobilization level can be clarified. This balanced case has not yet been implemented by FPA, but efforts are being made to implement this

Table 4. RANGE OF ASSUMPTIONS CONCERNING RISK

Risk	Mobilization		Size of Stockpile
	Limited	Full	
1	Safer	Safer	Larger
2	Less Safe	Less Safe	Smaller
3 {	DoD Quite Safe	Quite Safe	} Balanced
	EC Less Safe	Less Safe	
	OC At Risk	At Risk	

scenario computationally in the near future. The range of assumptions presented has been drawn up by FPA; the final choice of a scenario is made by the National Security Council.

## 1. Consumption

Two decisions are made concerning levels of consumption: (1) whether any limitations are to be imposed on consumption, i.e., some form of austerity; and (2) whether any change is to be assumed in the composition of consumption, particularly the division between durable and nondurable goods. Tables 5 and 6 summarize the assumptions made; Table 7 provides some historical data for comparison.

(1) Austerity. Table 5 summarizes the assumptions made concerning austerity. In effect they assume that no substantial reductions in consumption levels will occur, but hold consumption levels at or near the pre-war levels. For the limited mobilization case with higher dependence on the stockpile, consumption is allowed to increase freely.

Between 1929 and 1974 the average rate of growth of consumption has been at an annual rate of 2.98 percent. The rate of growth of consumption during the 1939-45 period of limited and full-scale mobilization was *above* this historical norm with a 3.57 percent growth rate; and for the full-scale mobilization period, consumption grew at 4.27 percent per year. (This seems paradoxical in the face of rationing, but rationing during the war was often geared to the conservation of specific critical and strategic materials. Gasoline was rationed primarily to conserve rubber.) The growth of consumption during the Korean conflict was at a rate of 2.85 percent. Historically austerity has not been part of the American wartime experience except from the elimination of some nonessential consumption through controls and rationing geared to free specific strategic materials.

Table 5. AUSTERITY: WARTIME CONSUMPTION AS A PERCENTAGE OF PEACETIME

Risk	Mobilization					
	Limited			Full		
	Year			Year		
	1	2	3	1	2	3
1	none <sup>a</sup>	none	none	100	100	100
2	100	100	100	100	95	90
3 $\left\{ \begin{array}{l} \text{DoD} \\ \text{EC} \\ \text{OC} \end{array} \right\}$	100	100	100	100	100	100

<sup>a</sup>No austerity imposed.

Table 6. PERCENT SHIFT IN PCE FROM DURABLES TO NONDURABLES

Risk	Mobilization					
	Limited			Full		
	Year			Year		
	1	2	3	1	2	3
1	25	25	25	25	50	75
2	50	50	50	50	75	75
3 $\left\{ \begin{array}{l} \text{DoD} \\ \text{EC} \\ \text{OC} \end{array} \right\}$	25	25	25	25	50	75

Table 7. HISTORICAL DATA ON CONSUMPTION  
(Billions of 1958 Dollars)

Year	Consumption	Durables	Non-Durables	Services	Durables Shift <sup>a</sup>
1939	148.2	14.5	81.2	52.5	
1940	155.7	16.7	84.6	54.4	
1941	165.7	19.1	89.9	56.3	
1942	161.4	11.7	91.3	58.5	30.4
1943	165.8	10.2	93.7	61.8	46.6
1944	171.4	9.4	97.3	64.7	50.8
1945	183.0	10.6	104.7	67.7	44.5
1946	203.5	20.5	110.8	72.1	
1947	206.3	24.7	108.3	73.4	
1948	210.8	26.3	108.7	75.8	
1949	216.5	28.4	110.5	77.6	
1950	230.5	34.7	114.0	81.8	-29.0
1951	232.8	31.5	116.5	84.8	-17.1
1952	239.4	30.8	120.8	87.8	-14.5
1953	250.8	35.3	124.4	91.1	-31.2

<sup>a</sup>The shift parameter is  $k_t$ , defined by  $D_t = (1-k_t)D_0$  where  $D_t$  is the production of durables in year  $t$ , and  $D_0$  is a base period. For the World War II data  $D_0 = 16.8$ , the average for 1939-41; for Korea  $D_0 = 26.9$ , the average for 1946-50.

(2) Durable Goods. Consumption is normally divided into durable and nondurable expenditures. Durable consumption expenditures are items such as cars and home appliances, items for which purchases often can be postponed by repair and a willingness to live with older models. Purchases of nondurables such as food and clothing are less likely to be postponed. The interest in how consumption is divided between durables and nondurables stems from the fact that fewer basic, critical materials go into nondurables than durables. If consumers postpone their purchases of durable goods, they free more critical materials for other applications and place less burden on stockpile requirements.

The assumption employed by the proposed FPA guidance is that there is a shift away from durable goods toward nondurables. The purchases of durable goods during each year of the war,  $D_t$ , is defined as

$$D_t = (1-k_t)D_0, \quad t = 1,2,3$$

where  $D_0$  is the consumption of durable goods at the time the war commences. Table 6 shows these assumed values for  $k_t$  for the various scenarios;  $k_t$  ranges from a 25 to a 75 percent reduction in durables over the course of the war. The right-most column of Table 7 shows the actual shifts during World War II and the Korean conflict. During World War II, up to 50 percent of the pre-war annual durable consumption was postponed. In Korea, however, purchases of durables grew rapidly throughout the war and there was no evidence of any shift away from them.

Next to the historical record, the shift values assumed appear to be large. There is little evidence that a limited mobilization induces much change in the consumption of durables. Comparatively strong measures (in World War II such strong measures were exercised through the allocation of basic

materials to more essential wartime production, but through some rationing as well) saw durable purchases fall by half. If shifts away from durables of the magnitude forecast do not materialize, the stockpile levels might be insufficient.

## 2. Investment

Fixed investment has characteristics similar to consumption to the extent that (1) some of it can be postponed under emergency conditions, and (2) its composition may change between wartime and peacetime conditions. Table 7 summarizes historical data on private fixed investment, categorized as investment in residential structures and producers durable equipment.

### a. Size and Composition of Investment

The only assumption made by the FPA guidance concerning investment is that its composition will change. It is assumed that the shift from peacetime to wartime production patterns will result in a reduction in the construction of structures (especially private residences) and a shift to producers durable equipment. The shift is defined in a completely analogous manner to that used for the shift from nondurable to durable consumption in the preceding section. The residential investment during year  $t$  of the war ( $r_t$ ) is

$$r_t = (1-h_t)r_0,$$

where  $r_0$  is a pre-war level of investment. Similarly, nonresidential investment is defined as

$$n_t = (1-j_t)n_0,$$

where  $n_0$  is base-year investment. Two values are assumed for the "shift" parameters  $h_t$  and  $j_t$  depending on the stage to which the mobilization has advanced, described as "transitional" and "wartime" levels.

Transitional:  $h_t = 0.50$

$j_t = 0.25$

Wartime:  $h_t = 0.75$

$j_t = 0.25$

The assumptions for the mobilization and risk levels are shown in Table 8. P is peacetime, T is transition periods, and W is wartime. Some shift occurs in every case, but the wartime pattern occurs only under full mobilization.

Table 8. GUIDANCE ASSUMPTIONS CONCERNING THE COMPOSITION OF FIXED INVESTMENT

Risk	Mobilization					
	Limited			Full		
	Year			Year		
	1	2	3	1	2	3
1	T	T	T	T	W	W
2	P	T	T	P	T	W
3	T	T	T	T	$\frac{T+W}{2}$	W

Table 9 shows the historical shifts during World War II and the Korean conflict. The high risk/small stockpile assumptions under the limited mobilization correspond closely to the pattern assumed; the "low risk" assumptions assume that the shift in composition occurs more slowly than the historical record. In Korea there is no evidence of a shift occurring at all, as both total fixed investment and each share remained fairly constant. This is in contrast to the slow but definite shifts assumed in the scenario for the

Table 9. HISTORICAL DATA ON FIXED INVESTMENT  
(Billions of 1958 Dollars)

Year	Fixed Investment	Residential Structures	Non-Residential Structures	Producers Durable Equipment	Shift from Residential Structures <sup>a</sup>	Shift from Non-Residential Structures <sup>a</sup>
1939	23.5	8.2	2.9	9.4		
1940	28.1	9.2	6.8	12.1		
1941	32.0	9.8	8.1	14.2		
1942	17.3	4.9	4.6	7.9	0.46	0.33
1943	12.5	2.9	2.9	7.2	0.68	0.57
1944	15.9	2.5	3.8	9.6	0.73	0.45
1945	22.6	2.8	5.7	14.1	0.69	0.17
1946	42.3	12.1	12.5	17.7		
1947	51.7	15.4	11.6	24.6		
1948	55.9	17.9	12.3	25.7		
1949	51.9	17.4	11.9	22.6		
1950	61.0	23.5	12.7	24.8		
1951	59.0	19.5	14.1	25.5	-0.12	-0.15
1952	57.2	18.9	13.7	24.6	-0.09	-0.12
1953	60.2	19.6	14.9	25.8	-0.12	-0.22

<sup>a</sup>The base values were the annual average from 1939-41 for World War II ( $r_0 = \$9.1b$ ;  $n_0 = \$6.9b$ ); from 1946-49 for Korea ( $r_0 = \$17.3b$ ;  $n_0 = \$12.2b$ ).

limited mobilization. Curiously, when compared to the historical record, the policies assumed seem somewhat optimistic for the limited mobilization by assuming investment in structures will be limited; and it seems comparatively pessimistic for full mobilization by taking the World War II pattern as the riskiest case.

#### b. Investment During a Mobilization

One of the criteria (of Chapter I) for judging a model, which is to reflect the economics of a mobilization was that it should include a major expansion of capital facilities in defense-oriented industries. This kind of expansion should occur during a limited mobilization as well as a maximum effort, as the limited mobilization is primarily a means of preparing for a potentially larger conflict. The total investment figure used by FPA is that projected by the MCL-Thurow Model; it is inadequate in at least two ways even after policy assumptions are made to shift its composition. To induce a major expansion of defense-oriented production, tax and other incentives have historically been offered by the government for capital construction undertaken to support the war. This alters the behavioral responses upon which an historical model such as MCL-Thurow must rely. Also, the government may build substantial numbers of facilities without relying on the private sector at all. The line between private and public expenditures is thin enough to become meaningless.

The problem is that the "uses of income" conventions used by the MCL-Thurow Model become blurred in wartime. The peacetime government policy is that, whenever feasible, all contractors for government procurements should provide their own plant and equipment. This is counted as private fixed investment, even though sales are to the government. But during World War II and the Korean conflict, procedures were adopted to greatly expand the military production base. Some \$16 billion of production facilities, for example, were built by the Defense Plant Corporation and then leased to industry. These expenditures are counted as public rather than private investment expenditures. Other schemes, such as guaranteed

<sup>1</sup>Harry B. Yoshpe, et al., *Production for Defense* (Washington, D.C.: Industrial College of the Armed Forces, 1968), p. 45.

financing or rapid depreciation, induced private expenditures for defense and some private investment. It becomes rather arbitrary whether the expenditures for many defense plants are counted as government or private spending. A consolidated investment figure jointly considering private investment for private production, private investment for public production, and public investment in support of the mobilization would seem more appropriate for mobilization periods.

Table 10 shows the type of combined statement that might better reflect investment requirements, using World War II as an example. Total Private Fixed Investment is taken from Table 9. \$12.0 billion of this private investment was for military production capacity, with accelerated amortization and guaranteed government financing used as incentives to the private sector to undertake the investment. Military facilities involved \$20 billion in investment, and \$32 billion was spent to provide production capacity which was then leased to private contractors. On balance, the military investment requirements were \$7.1 billion higher than private investment during World War II.

The Korean conflict re-emphasized this pattern as the Services furnished \$3 billion in facilities to contractors.<sup>1</sup> Accelerated amortization in Korea was allowed on \$25 to \$30 billion of investment for defense purposes, and was worth roughly \$17 billion to contractors.<sup>2</sup> Perhaps as much as \$20 billion of investment was induced directly by mobilization during the Korean conflict.

The U.S. has operated at comparatively high levels of military preparedness since World War II, but a major war

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<sup>1</sup>Harry B. Yoshpe, et al., *Production for Defense* (Washington, D.C.: Industrial College of the Armed Forces, 1968), p. 45.

<sup>2</sup>George A. Lincoln, *The Economics of National Security*, 2nd ed. (Englewood Cliffs, N.J.: Prentice Hall, 1958), p. 345.

The U.S. has operated at comparatively high levels of military preparedness since World War II, but a major war effort would undoubtedly require very substantial expenditures to expand current production lines. Material requirements for such an expansion have to be considered explicitly in calculating stockpile requirements. A joint balance sheet such as Table 10 would seem a necessity if investment flows and the materials to assure these flows are to be available under emergency conditions. FPA should be urged to remedy the neglect of this problem in current computations of stockpile objectives.

Table 10. TOTAL FIXED INVESTMENT--PUBLIC AND PRIVATE--  
DURING WORLD WAR II  
(Billions of 1958 Dollars)

Private		Public	
Residential	\$17.0	Military Facilities	\$20.0
Non-Residential	13.1	Military Production Capacity	<u>32.0</u>
Producers Equipment	<u>38.8</u>	Total Military Financed	\$52.0
Total	\$68.9	Private for Military Use	<u>12.0</u>
For Military Use	<u>-12.0</u>	Total Military	\$64.0
For Non-Military	\$56.9		
Sources: <i>Economic Report of the President, 1975, op. cit.</i> ; George A. Lincoln, <i>The Economics of National Security</i> , 2d ed. (Englewood Cliffs, N.J.: Prentice-Hall, 1958), p. 345.			

### 3. Government Spending

In this section we will review the assumptions made concerning defense and other federal spending, and spending by state and local governments. All federal spending is strictly exogenous to the model, but state and local spending is forecast by the MCL-Thurow Model. Government spending is obviously a crucial part of predicting the economic effects of a mobilization as defense spending effectively drives the new output requirements upward.

#### a. Department of Defense Expenditures

DoD expenditures during a mobilization have been estimated by program, by line item, or by groups of line items corresponding to the Budget of the United States Government.<sup>1</sup> Estimates of the pattern of expenditures for 1976 and for each year of a three-year limited mobilization are shown in Table 11; the same data for a full mobilization are shown in Table 12. These data are now recognized as old and dated, and FPA is working with the Department of Defense to derive new expenditure patterns.

One relatively minor change is suggested for collecting and displaying these data. The first line item in Tables 11 and 12 is the cost of uniformed military personnel. Civilian personnel are not budgeted on any one line, but their salaries are some fraction (varying from line to line) of each individual category. Civilian salaries *can* be removed from each line item (using the DoD "bridge" tables described in the next chapter), and we would like to suggest that data collection specify *both* civilian employment and the purchase of goods

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<sup>1</sup>Department of Defense, *The Budget of the United States Government: DoD Extract for FY77* (Washington, D.C.: GPO, 1976).

Table 11. PATTERN OF DEFENSE EXPENDITURE UNDER  
A LIMITED MOBILIZATION  
(\$ 1958)

Budget Line Items	Current	Year 1	Year 2	Year 3
Military Personnel (97221)	8966.8	17123.6	20488.9	20903.0
Operations & Maintenance (97222)	10998.9	18193.8	21464.5	22893.8
Research & Development (97223)	7788.9	6421.3	5951.5	6171.4
Family Housing (97224)	355.3	647.5	1180.5	1505.0
Military Construction (97225)	422.7	1391.3	2536.7	3236.0
Civil Defense (97226)	30.7	101.7	185.4	235.9
Aircraft (97331)	4353.2	8775.8	9854.2	16921.5
Army Missiles (97341)	710.7	531.9	679.1	775.4
Navy Missiles (97342)	600.8	642.1	820.5	936.7
Air Force Missiles (97343)	1161.1	2000.2	2551.4	2912.5
Marine Missiles (97344)	22.8	36.4	46.8	53.8
Shipbuilding & Conversion (97351)	1423.4	2425.1	3146.5	5813.0
Ship Support (97352)	227.7	357.5	463.4	856.0
Army E & C (97361)	343.5	896.8	1601.1	2572.1
Navy E & C (97362)	266.3	668.9	1194.2	1917.1
Air Force E & C (97363)	254.4	795.2	1419.6	2281.4
Marines E & C (97364)	74.2	207.6	370.8	595.2
Army Ammunition (97371)	1094.7	3357.3	5469.6	7023.4
Navy Ammunition (97372)	291.0	1701.7	2773.8	3562.5
Air Force Ammunition (97373)	529.6	2828.6	4609.0	5919.5
Marine Ammunition (97374)	139.6	674.2	1099.6	1411.5
Army Weapons & Vehicles (97381)	245.5	1238.2	1752.3	2621.8
Army Tactical Vehicles (97382)	239.5	1176.2	1664.5	2489.5
Army Support (97383)	308.8	1381.7	1953.3	2923.4
Navy Civil Engineering (97384)	102.9	382.1	540.5	808.3
Navy Supply Support (97385)	50.5	161.6	228.3	341.4
Marine Support Vehicles (97386)	54.4	176.6	249.8	374.3
Marine Engineering (97387)	36.6	114.5	162.0	242.9
Air Force Vehicles (97388)	100.0	313.6	442.9	663.9
Air Force Support (97391)	275.2	1262.9	1787.4	2673.6
TOTAL DEFENSE EXPENDITURES	41,469.7	75,958.9	96,688.1	121,635.8

Table 12. PATTERN OF DEFENSE EXPENDITURES  
UNDER FULL MOBILIZATION  
(\$ 1958)

Budget Line Items	Current	Year 1	Year 2	Year 3
Military Personnel (97221)	8966.8	17123.6	30521.6	36692.0
Operations & Maintenance (97222)	10998.9	18193.8	31975.0	40186.4
Research & Development (97223)	7788.9	6421.3	8865.8	10832.9
Family Housing (97224)	355.3	647.5	1758.6	2641.8
Military Construction (97225)	422.7	1391.3	3778.9	5680.3
Civil Defense (97226)	30.7	101.7	276.1	414.1
Aircraft (97331)	4353.2	8775.8	14679.4	29703.0
Army Missiles (97341)	710.7	531.9	1011.6	1361.1
Navy Missiles (97342)	600.8	642.1	1222.3	1644.1
Air Force Missiles (97343)	1161.1	2000.2	3800.7	5112.4
Marine Missiles (97344)	22.8	36.4	69.8	94.4
Shipbuilding & Conversion (97351)	1423.4	2425.1	4687.2	10203.9
Ship Support (97352)	227.7	357.5	690.4	1502.6
Army E & C (97361)	343.5	896.8	2385.0	4514.9
Navy E & C (97362)	266.3	668.9	1779.0	3365.2
Air Force E & C (97363)	254.4	795.2	2114.7	4004.7
Marines E & C (97364)	74.2	207.6	552.3	1044.8
Army Ammunition (97371)	1094.7	3357.3	8147.8	12328.5
Navy Ammunition (97372)	291.0	1701.7	4132.0	6253.4
Air Force Ammunition (97373)	529.6	2828.6	6865.9	10390.8
Marine Ammunition (97374)	139.6	674.2	1638.0	2477.6
Army Weapons & Vehicles (97381)	245.5	1238.2	2610.3	4602.2
Army Tactical Vehicles (97382)	239.5	1176.2	2479.5	4369.8
Army Support (97383)	308.8	1381.7	2909.7	5131.6
Navy Civil Engineering (97384)	102.9	382.1	805.2	1418.8
Navy Supply Support (97385)	50.5	161.6	340.1	599.3
Marine Support Vehicles (97386)	54.4	176.6	372.1	657.0
Marine Engineering (97387)	36.6	114.5	241.3	426.3
Air Force Vehicles (97388)	100.0	313.6	659.8	1165.4
Air Force Support (97391)	275.2	1262.9	2662.6	4693.1
TOTAL DEFENSE EXPENDITURES	41,469.7	75,958.9	143,632.7	213,512.4

for each line item. The MCL-Thurow Model already makes this same distinction between goods, purchases, and government employment, and it would seem desirable to carry this distinction over to the expenditure patterns.<sup>1</sup>

Failure to break out the data as suggested has led to some confusion and inconsistencies in the past. Earlier estimates using the FPA system have assumed no expansion of DoD civilian personnel in the data input to the MCL-Macro Model,<sup>2</sup> but an expansion was clearly implicit in the defense expenditure pattern. Total DoD civilian salaries will be roughly proportional (13 to 15 percent) to DoD expenditures and they expand rapidly with the build-ups outlined in Tables 11 and 12.

Table 13 shows that civilian DoD employment has grown rapidly in wartime, and both the macroeconomic model and the defense expenditure patterns should reflect this. Defense civilian employment climbed rapidly both during World War II and the Korean conflict. Between 1942 and 1944 it slightly less than doubled; as total DoD expenditure more than tripled, these civilian expenditures fell as a proportion of the total budget. Much the same pattern occurred in the Korean emergency, as employment and total defense expenditures followed the World War II case rather closely.

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<sup>1</sup>The original data were derived in the 1963-66 period and have been used since. It would be difficult to assess their adequacy without deriving a new set of data. They are based strictly on military considerations and are not forecast by the model.

<sup>2</sup>E.P. Rosenberg, "Projected Gross National Product MCL-Thurow Model Output," FPA memorandum dated 20 June 1975. It should also be noted that the expenditure pattern and the assumption of 5, 10, and 15 million men in the Armed Services were also inconsistent with the pay scales assumed. The assumption of 5, 10 and the 15 million men in uniform was a recent assumption not reconciled with the expenditure patterns. Mr. Ron Hurdelbrink of FPA assures us that they have brought the various parts of the model into line and that it is now consistent on all of these points.

Table 13. GOVERNMENT EMPLOYMENT, 1939-1953

Year	Federal Employment				State and Local Employment
	Non-Defense	Defense Civilian	Military	Total	
1939	313	196	335	844	2,890
1940	323	256	458	1,037	3,226
1941	335	556	1,801	2,692	3,320
1942	338	1,291	3,859	5,488	3,270
1943	339	2,200	9,045	11,584	3,174
1944	374	2,247	11,452	14,073	3,116
1945	416	2,644	12,124	15,184	3,137
1946	453	1,416	3,030	4,899	3,341
1947	445	859	1,583	2,887	3,582
1948	475	871	1,446	2,792	3,787
1949	501	880	1,615	2,996	3,948
1950	484	753	1,460	2,697	4,098
1951	482	1,236	3,250	4,968	4,087
1952	508	1,337	3,636	5,481	4,188
1953	507	1,332	3,555	5,394	4,340

A second consideration that might improve the input to the model would be to break down the salary schedules more finely than they have been in the past. The MCL-Thurow Model pays federal salaries (both military and civilian) of \$4760.9 per worker.<sup>1</sup> These might be compared to a finer breakdown of salaries<sup>2</sup> of \$4873.0 for defense civilian employees, \$5953.1 for other federal employees, \$3685.9 for the

<sup>1</sup>"MCL-Thurow Model," *op. cit.*

<sup>2</sup>Provided by Margaret Buckler of the INFORUM Project at the University of Maryland.

military, \$4574.1 for state and local education, and \$4309.0 for other local employees. The finer breakdown would seem desirable here since there will be a major change in the mix or composition of government employees; the mix will shift sharply in favor of the military who are by far the lowest paid workers. Paying the average salary to all federal government workers in the FPA model results in a clear over-estimation of military manpower cost during the mobilization.

b. Other Federal Spending

It is assumed that the number of federal employees other than those employed by the Defense Department remain unchanged throughout the war, as do purchases of other goods and services. The historical employment pattern is shown in Table 13.

c. State and Local Governments

State and local employment and purchases of goods and services are predicted using regression equations from the Thurow econometric model. Goods and services per capita (G/P) and employment per capita (E/P) are predicted in 1958 dollars using the Gross National Product lagged one year (GNP-1), school expenditures per capita (S/P), and federal grants-in-aid per capita (GA/P). The estimated relations are:

$$E/P = -0.00365 + 0.00387 \text{ GNP}(-1) + 0.15813 \text{ GA/P} + 0.11638 \text{ S/P};$$

$$G/P = -0.14202 + 0.04276 \text{ GNP}(-1) + 0.821649 \text{ S/P} + 0.85994 \text{ GA/P} .$$

Both mobilization levels lead to small or negative growth rates for state and local expenditures. This generally conforms with historical experience, as Table 13 indicates very slow expansion of state and local employment during both the Korean conflict and World War II.

#### 4. Exports and Imports

Exports and imports again are treated in terms of "shifts" from some base year to higher or lower levels throughout the course of the war. The shift in exports ( $E_t$ ) and imports ( $M_t$ ) is defined in a manner analogous to the shifts in consumption patterns.

$$E_t = (1-k_t)E_0 .$$

$$M_t = (1-j_t)M_0 .$$

Tables 14 and 15 show the assumed values of the shift parameters; Table 16 shows the historical pattern in World War II and Korea, and the shifts in exports from base-year data.

A cursory comparison of the assumptions with the historical data reveals that they run exactly counter to each other. Historically, exports (due to controls and lost markets) have fallen and imports (due to expanded wartime demands) have risen rapidly. The suggested scenario assumes just the opposite. The scenario is drawn up with apparently only the "risk" concept under consideration; that is, if sufficiently conservative assumptions are made--regardless of fact--the matter is properly settled. Import reductions and export expansion are increased or decreased in accordance with the extent of reliance on the stockpile (or "risk"), and with little else in mind except some (unspecified) adjustment for shipping losses. Huge costs in imports of essential consumer items assumed here imply (a) more reliance must be placed on the domestic economy; and (b) more reliance must be placed on the stockpile to support domestic production. A study of the likely impact of export controls and lost wartime markets, as well as expanded wartime foreign (though not necessarily strategic or critical) needs, might reveal a very different set of assumptions. Conservative assumptions for their own sake are not in the best interest of the stockpile policy and only harm its credibility.

Table 14. SHIFT IN EXPORTS UNDER MOBILIZATION

Risk	Mobilization					
	Limited			Full		
	Year			Year		
	1	2	3	1	2	3
1	-20	-15	-5	-20	-10	-5
2	10	15	20	10	15	20
3 {	DoD <sup>a</sup>	--	--	--	--	--
	EC	-20	-20	-10	-20	-15
	OC	20	10	0	25	70

<sup>a</sup> DoD supplied only from assured sources.

Table 15. SHIFT IN IMPORTS UNDER MOBILIZATION

Risk	Mobilization					
	Limited			Full		
	Year			Year		
	1	2	3	1	2	3
1	40	35	30	40	40	40
2	20	10	10	20	20	20
3 {	DoD <sup>a</sup>	--	--	--	--	--
	EC	50	40	35	60	50
	OC	10	0	0	10	10

<sup>a</sup> DoD supplied only from assured sources.

Table 16. HISTORICAL DATA ON IMPORTS AND EXPORTS

Year	Exports	Imports	Export <sup>a</sup> Shift	Import <sup>b</sup> Shift
1939	10.0	8.7		
1940	11.0	8.9		
1941	11.2	10.8		
1942	7.8	9.9	0.27	-0.04
1943	6.8	12.6	0.36	-0.33
1944	7.6	13.4	0.29	-0.41
1945	10.2	13.9	0.14	-0.46
1946	19.6	11.2		
1947	22.6	10.3		
1948	18.1	12.0		
1949	18.1	11.7		
1950	16.3	13.6	0.17	-0.20
1951	19.3	14.1	0.02	-0.24
1952	18.2	15.2	0.07	-0.34
1953	17.8	16.7	0.09	-0.41

<sup>a</sup>The shift is  $k_t$  where  $E_t = (1-k_t)E_0$ , where  $E_t$  are exports during the war and  $E_0$  a base period.  $E_0 = 10.7$  is the 1939-41 average before World War II, and  $E_0 = 19.6$  is the 1946-49 average for Korea.

<sup>b</sup> $M_t = (1-j_t)M_0$  where  $M_0 = 9.5$  is the 1939-41 average;  $I_0 = 11.3$  is the 1946-49 average.

### C. SENSITIVITY OF THE MODEL TO THE SCENARIO ASSUMED

Given the basic charge of planning for a mobilization of uncertain duration and magnitude, the National Security Council and FPA necessarily face a dilemma in choosing any one plan upon which to base the stockpile. How do such uncertainties affect the requirements for materials? In this section we have used a hypothetical baseline mobilization as a starting point, and then made six policy changes in the basic assumptions to gauge their effect on material needs. The basic mobilization was described by use of income in Table 2, and it is similar in composition and magnitude to the guidance used by FPA in past years. The policies were simulated on the University of Maryland's INFORUM model. Chapter IV will demonstrate the close similarity between the projections of this model and those of FPA. The results found here almost certainly are equally applicable to FPA's model.

Table 17 shows the baseline requirements for fourteen materials in the left-most columns. The percentage change in these material requirements resulting from six policy changes are shown on the right.

#### Policy Change A: Reduce Personal Consumption Expenditure by Six Percent

This is a reduction of about \$50 billion in spending. The assumption of some austerity reduces material requirements for all materials except titanium, and reduces the need for platinum by nearly seven percent. The reduction exceeds three percent for only four materials.

#### Policy Change B: Shift 30 Percent of Durable Goods Consumption to Nondurables and Services.

This reduces durable good spending about \$80 billion but leaves the total spending unchanged. This has a substantially greater effect in reducing material needs than Policy Change A, as over half of the material needs shift by five percent or more. Feathers, opium, and quinine increase as they are used in nondurables (bedding, food, and medicines), while the rest of the material requirements fall.

Table 17. PERCENT CHANGE IN MATERIAL REQUIREMENTS FOR  
SIX POLICY CHANGES DURING A MOBILIZATION

Material	Baseline	Requirements	Policies					
			A	B	C	D	E	F
Antimony	46,515	SH TONS	-2.2	-5.0	-7.2	10.2	7.7	3.5
Beryl	17,238	SH TONS	-0.7	-1.6	0.0	13.5	10.3	9.8
Bismuth	2,952	TH LBS	-2.0	-1.8	-8.8	8.7	8.2	4.6
Cadmium	19,580	TH LBS	-4.7	-6.1	-4.0	16.7	9.1	10.9
Feathers	10,401	TH LBS	-0.4	7.3	-9.6	2.7	2.5	3.0
Lead	2,048	TH SH TONS	-2.1	-4.6	-7.4	11.7	6.9	4.7
Nickel	229,525	SH TONS	-1.6	-9.3	-5.1	14.8	13.0	5.0
Opium	515,000	LBS	-4.7	8.2	-0.2	0.0	0.0	0.0
Platinum	1,073	TH TROY OZ	-6.9	-0.4	-2.0	4.7	3.4	2.9
Quinine	3,739	TH AVOIR OZ	-4.5	8.3	-0.2	0.2	0.1	0.5
Rutile	356,803	SH TONS	-1.4	-1.3	-0.4	9.9	3.7	3.3
Silver	196,142	TH TROY OZ	-0.1	-0.1	-1.2	12.6	10.2	3.5
Tantalum	3,716	TH LBS	-2.7	-5.6	-0.4	9.2	9.1	11.3
Titanium	35,305	SH TONS	0.0	0.0	0.4	8.4	8.2	16.1

Policy Change C: Halt All Consumer Purchases of Autos

Auto, truck, and trailer production for war and investment continue, but consumer sales are stopped. This represents a drop of \$35 billion in durable goods consumption. Because autos use materials so intensively, the downward shift in material requirements is large, and it exceeds the changes in Cases A and B where the dollar magnitudes involved in the changes were much bigger.

Policy Change D: Increase Investment in Producers Durable Equipment and Nonresidential Structures by 50 Percent Each.

This is a combined increase in spending of nearly \$80 billion. The size of the new material requirements reflect both the large dollar increase and the material-intensive nature of capital production.

Policy Change E: Repeat Policy Change D, but Set Residential Construction to Zero.

This is another form of civilian austerity, and it reduces residential spending by \$30 billion from Policy Change D. Some materials requirements fall substantially when compared to D (cadmium, lead, rutile) and other (bismuth, nickel, silver) do not. The differences seem entirely consistent with the use of the materials in various types of construction.

Policy Change F: Increase Defense Spending by \$24 Billion for Goods and Services

This is a 13 percent change in defense spending, but with 30 percent or more of this going for salaries and payments for services which do not consume materials. Materials extensively used in defense applications--beryl, cadmium, tantalum, and titanium--responded very significantly to DoD purchases.

Given the uncertainties involved in scenario building for a future war, it is unlikely that any of the policy changes outlined could be easily dismissed. Yet very substantial changes in stockpile requirements do result from shifting policies. Any assessment of the adequacy and accuracy of the model must take this tremendous uncertainty as a starting

point. The remainder of this report is couched in terms of accuracy given the basic scenario. No model can compensate for inaccurate assumptions made at the scenario level, and uncertainties here will remain with us in every projection made no matter how good the model may be; however, a good model must be consistent with these assumptions and must reflect them accurately.

#### D. CONCLUSIONS

This chapter has reviewed the basic assumptions upon which any projection of material requirements must be based. The basic conclusion is that the highly specific assumptions required by the model are difficult to formulate because of uncertainties involved in the planning process. The choice of any one scenario is a subjective and speculative process given the vicissitudes of international relations. No matter how the scenario is chosen, great uncertainty must persist concerning its ability to finally reflect the future. This basic uncertainty carries through to the estimates of material requirements and cannot be reduced by any modeling process. A good model will simply do a good job of reflecting possibly dubious assumptions.

More specific conclusions can be drawn as follows concerning the scenario.

- There seem to be problems in FPA's investment planning. Expansion of capital facilities to expand wartime production appears to have been totally neglected. This results from basic definitional problems in using the "uses of income" definitions, but it can be easily remedied within the context of the current model.
- The breadth of choices of scenarios offered by FPA is quite wide. They have made little headway in providing a meaningful rationale to choose among them, and the uncertainties surrounding the potential use of the stockpile admittedly make this difficult. The official

sanction given the scenario chosen by the National Security Council and FPA does not go far in reducing this uncertainty, and the scope of this uncertainty must be recognized.

- Lacking good rationales for describing possible shifts in the uses of income for some flows, it appears that FPA has made a decision to "play safe" by making conservative assumptions. There are other means of describing possible changes in income flows in some of these cases. Conservative assumptions for their own sake may simply hurt the credibility of the entire planning process.
- The scenario does affect material needs in a significant way. A series of policy changes made in a one-at-a-time manner produced broad shifts in material needs. Working together as a series of assumptions in a scenario, extensive changes in material needs could be produced by these policy changes. The scenario must be counted as a major source of uncertainty when judging material requirement estimates.

## Chapter III

### IMPLEMENTING THE INPUT-OUTPUT ANALYSES

This chapter will review the implementation of input-output analysis in the FPA computations. Input-output is an extremely simple concept that appears complex only when implemented on a larger scale. Accordingly, the first part of this chapter is a small example which makes explicit the assumptions and the data requirements for a bigger model. We can solve the example with elementary arithmetic; the only difference between the example and FPA procedures is the difficulty of mathematically solving a bigger problem. All the concepts remain the same between the example and FPA's model; the problems and questions unearthed will apply to the larger scheme as well.

#### A. A SMALL EXAMPLE

##### 1. The Data

Let's assume a small economy which produces only two goods--steel and aircraft. Only two sources of final demand or requirements exist for these goods, those of households for consumption and those for defense (we are ignoring foreign trade, investment, other government requirements, etc.). Labor is the only income-earning input and is provided by households. Table 18 summarizes the data required to construct an input-output model of this hypothetical economy.

Entries in the first row show that steel used \$10 of its own output (scrap, steel machinery), \$50 was sold to the aircraft industry, \$20 was purchased by households for

Table 18. TRANSACTIONS FOR AN INPUT-OUTPUT MODEL OF A  
HYPOTHETICAL ECONOMY (DOLLARS)

To From	Steel (\$)	Aircraft (\$)	Households (\$)	Defense (\$)	TOTAL (\$)
Steel	10.	50.	20.	20.	100.
Aircraft	40.	40.	50.	100.	230.
Households	50.	140.	5.	10.	205.
TOTAL	100.	230.	75.	130.	

consumption, and \$20 was purchased by the Defense Department. Aircraft sold \$40 of its output to the steel industry, purchased \$40 of its own output, and sold \$50 to households and \$100 to the Defense Department.

The last row shows that households sold \$50 of labor to steel, \$140 to aircraft, \$5 to itself (gardeners, baby-sitters), and \$10 to DoD. Labor is the only productive input in our model, and the sum of this row is equal to total value-added or (for this simple case) Gross National Product of \$205.

If this table is read by column rather than by row, it can be interpreted slightly differently, showing the inputs (rather than the sales) of each sector and the composition of final demand. Steel acquired \$10 of input from itself, \$40 of aircraft, and \$50 of labor to produce \$100 of output. Similarly, to produce \$230 of aircraft the industry used the following inputs: \$50 of steel, \$40 from itself, and \$140 of labor. The last two columns show the composition of final demand. (The "uses of income" in this model are equal to the total value-added--the only "source of income.") Each of the two columns show not only the *total* final demands by consumers and defense, but they also show this total

broken down by industry. Total consumption by households (\$75) consists of \$20 of steel, \$50 of aircraft, and \$5 of its own labor; Defense consists of \$130 of output purchased as \$20 from steel, \$100 from aircraft, and \$10 of labor.

Let's maintain the distinction made by reading Table 18 by its columns and regard the input-output model as consisting of two parts: the first two columns are transactions among industries and the last two are final demand columns. The first two columns are used to derive the table of *input-output coefficients*. If we take the value of output for each industry and divide through the first two columns, we obtain Table 19. The interpretation is the same as before but placed on a "per dollar" basis; a dollars worth of inputs (from steel, aircraft, and households) is necessary to produce a dollars worth of output. These coefficients are the basis of most input-output forecasting. If we assume these coefficients remain *unchanged* (no substitution is allowed, technology remains the same), we can forecast output requirements for *any* set of final demands.

Table 19. TABLE OF INPUT-OUTPUT COEFFICIENTS  
(DOLLARS PER DOLLAR)

From \ To	Steel	Aircraft
Steel	0.10	0.22
Aircraft	0.40	0.17
Households	0.50	0.61
TOTALS	1.00	1.00

## 2. Forecasting with Input-Output

Table 20 summarizes the data requirements for a forecast.

Table 20. DATA REQUIRED FOR A FORECAST USING  
INPUT-OUTPUT ANALYSIS

<div>From \ To</div>	Steel	Aircraft	Households	Defense
Steel	0.10	0.22	DHS	DdS
Aircraft	0.40	0.17	DHA	DdA
Households	0.50	0.61	DHH	DHd

The input-output table on the left is for steel (S) and aircraft (A), and on the right is a set of final demands on these industries and on households (HDS is demand by households for steel, DdS is the demand by Defense for steel, etc.).

Total demand for steel is

$$S = 0.10S + 0.22A + DHS + DdS;$$

total demand for aircraft is

$$A = 0.40S + 0.17A + DHA + DdA .$$

The final demands must be set exogenously. Assuming that a war occurs in our hypothetical economy, consumption remains the same as in Table 18, but Defense spending doubles. This expansion of Defense requirements sets off a complicated chain of events. The expanded needs for aircraft impose new needs for steel (and aircraft), and hence for more aircraft and steel as inputs to the steel and aircraft industries, and on and on. New final demands impose *direct* and *indirect* requirements for these goods as intermediate output.

To compute total requirements for our example is a trivial matter. Using the assumptions and the data in Table 20 we have:

$$\begin{aligned}
DHS &= 20 & DdS &= 40 \\
DHA &= 50 & DdA &= 200 \\
S &= 0.10S + 0.22A + 60, \\
A &= 0.40S + 0.17A + 250 .
\end{aligned}$$

If we solve these two equations treating S and A as two unknowns, we find  $S = 159.5$  and  $A = 377.6$  are the total output requirements. Table 21 compares these total outputs to the direct and indirect requirements for both industries.

Table 21. DIRECT, INDIRECT, AND TOTAL REQUIREMENTS  
IN A MOBILIZATION EXAMPLE

Requirement	Direct	Indirect	TOTAL
Steel	60	99.5	159.5
Aircraft	250	122.6	377.6

### 3. Some Questions Raised by the Example

The example above was simple and required only rudimentary techniques. In all essentials, it is no different from the larger problem solved by FPA. The most important thing that comes out of the solution to the problem is the distinction between total output and direct and indirect outputs. One of the criteria established in Chapter I to judge the FPA model was its ability to account for all intermediate outputs. The model does this and does it very well, but it becomes clear that there is a price attached. The model is easily computable only if there is no substitution or change in technology. Such changes are seen to be a possibility in emergency conditions and are suggested as important criteria for judging the model. Some adjustments for substitution are made by FPA, but (as we will see) the procedures are neither complete nor necessarily consistent.

In the rest of this report we will take up the following questions, all of which are raised by our example.

- The data requirements are clearly quite extensive for both the table and for the final demand columns. The Bureau of the Census and the Bureau of Economic Analysis provide much of this data and some are derived by FPA. Do the age and quality of the data affect the results?
- Capacity is not mentioned in the example, and it is not part of FPA's current model. Does it matter significantly? Can it be included?
- How is substitution handled? Among industries? Among materials?
- How do we get to the materials level? The industries in the input-output table are broad industrial sectors--steel, nonferrous metals, aircraft, electronics--which are very large compared to the markets for exotic materials such as beryllium, titanium, etc.

## B. THE DATA REQUIREMENTS

The data requirements were made clear from our example: a set of input-output coefficients showing the technology of American industries and a set of final demands by input-output sector. Each of these will be considered in turn in this section. The FPA model uses an 86 sector input-output table of the United States for 1958. The 86 sectors collectively exhaust all output and are necessarily broad groupings in many cases--chemicals, paper, autos, etc. Final demand is divided on the basis of the "uses of income" definition of GNP as described in the previous chapter.

### 1. The Input-Output Table

The input-output table describes the input requirements (in dollars) from each of the 86 sectors needed to produce one dollar of output by each sector. This is a description of the technology--the production or input/output relationships--among broad sectors of the entire economy. Over time we may

find that as the relative prices of materials change, the product mix, the production techniques, and the product designs may change.<sup>1</sup> Each of these can and *will* change the coefficients of an input-output table, and the description of the economy embodied in the table ought to change to reflect these new conditions. It is a watchword among input-output forecasters that change occurs slowly (which is well, as the 1972 table will not be available for a year or more). Lags in data availability of five or more years probably leave ample opportunity for technology to outstrip the model. Table 22 shows coefficient changes between 1967 and 1972 among industrial coefficients where sales to each buyer exceeded \$1 billion. A number of coefficients with smaller flows showed much more dramatic change, demonstrating that even over a five-year period, major sectors are subject to change. Figure 4 shows changes between 1947 and 1958 in the use of aluminum by user firms in the left panel. If these coefficients had not changed, they would lie on the heavy diagonal line; change seems to be the rule rather than the exception. The FPA model

Table 22. COEFFICIENT CHANGE BETWEEN 1967 AND 1972  
(\$ Million 1972)

Seller	Buyer	1967 Purchases	Ratio Coefficients 1967/1972
Iron Ores	Steel	1,770.3	1.117
Crude Petroleum	Petroleum Refining	13,954.5	0.905
Steel	Motor Vehicles	3,577.5	0.919
Steel	Other Structural Metals	1,977.4	0.949
Steel	Metal Cans	1,521.9	0.837
Steel	Construction, Oil Field	1,082.0	0.850
Copper	Non-Ferrous Wire	1,228.7	0.892
Source: Inter-Industry Forecasting Model at the University of Maryland			

<sup>1</sup>For a discussion of why these coefficients change see Per Sevaldson, "Changes in Input-Output Coefficients," Ch. 16 in Tibor Barna (ed.), *Structural Interdependence and Economic Development* (New York: St. Martin's Press, 1963).

now uses 1958 coefficients, and the right panel shows the projected changes in aluminum usage between 1958 and the early 1970s. Figure 5 shows all of these same results for the use of copper.

There are means of updating tables even if lags occur in data availability.<sup>1</sup> As we noted above, the right-hand panels of Figures 4 and 5 were projected into the 1970s; this was done essentially by expert review.

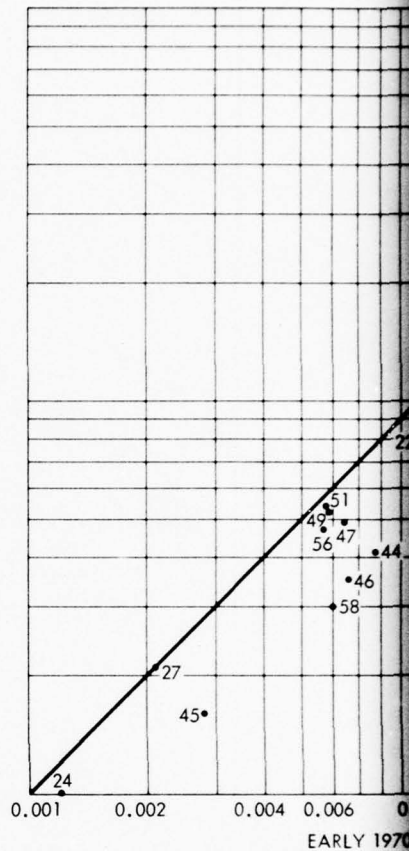
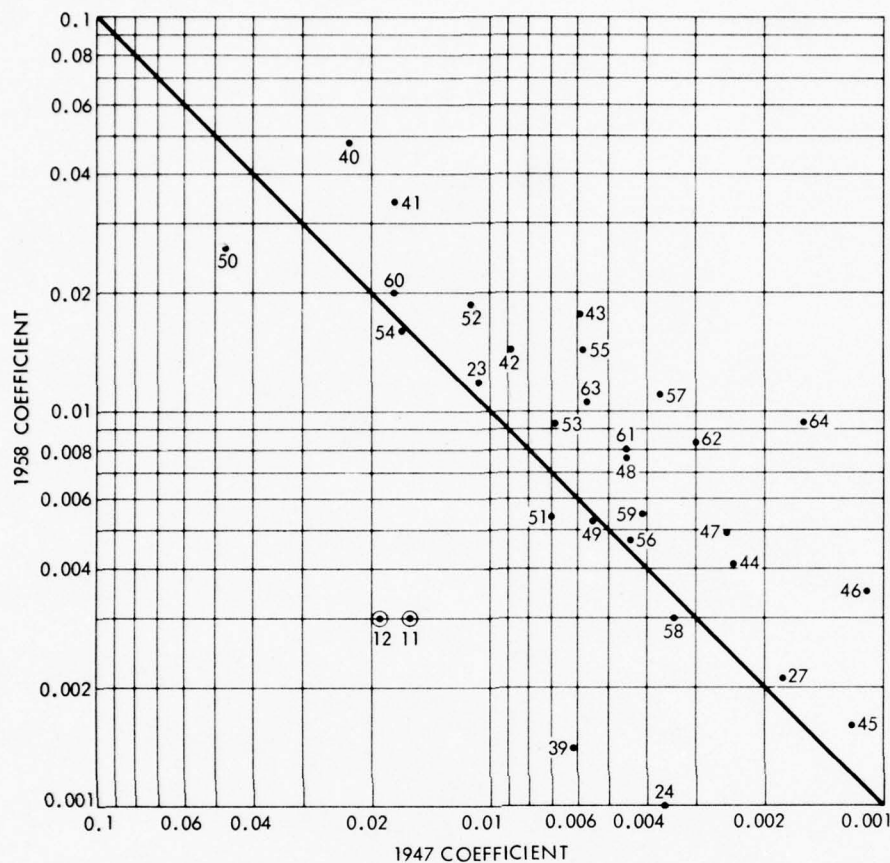
Most major changes in technology of production of product design can be anticipated by industry specialists five or more years before they are put into use....Given this key product information and general familiarity with price levels and trends in material markets, experts are in a position to predict material coefficients provided they work at a very fine level of detail.<sup>2</sup>

A strong rationale for expert review seems to exist. Trends in materials and industrial markets are reviewed regularly by the Commerce and the Interior Departments, and they could be called upon to assist in keeping the model abreast of material markets. Other means of updating the model by more mechanical

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<sup>1</sup>We disagree with FPA arguments against this, e.g. A.A. Schulman, *DITT Data Estimates and Input-Output Review*, IST 103, Office of Preparedness (February 1972), pp. 32-33. Several reasons against such updating are offered: (1) "...studies may provide reasonably good information on the direction of change but are less dependable in terms of the actual amount of change..."; (2) "...increased purchases of a given material is not sufficient information for an accurate coefficient change without comparable knowledge regarding...other materials classified in that sector..."; (3) "...agency interest is with final demand and total output, rather than intermediate relationships..."; (4) "...it is necessary to have many more personnel resources...." The first two reasons may be true for some cases but hardly provide a basis for blanket condemnation; the third is wrong as total output is the center of interest and is the sum of final demands and intermediate requirements.

<sup>2</sup>Anne P. Carter, *Structural Change in the American Economy* (Cambridge, Mass.: Harvard Univ. Press, 1970). The projections were done by Arthur D. Little, Inc., for Scientific American, Inc., in a study of technological change as indicated by basic shifts in I-O coefficients.

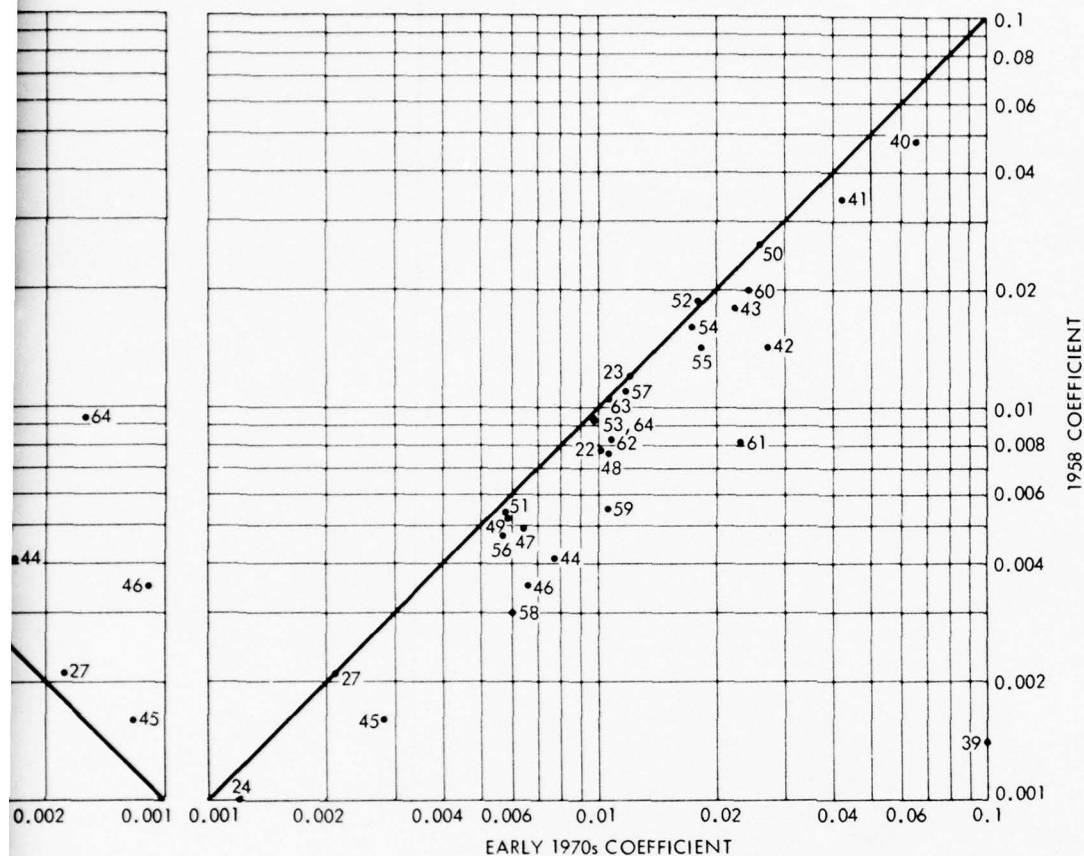


- |                          |                            |                         |                           |         |
|--------------------------|----------------------------|-------------------------|---------------------------|---------|
| (1) Livestock            | (14) Food                  | (29) Drugs, soaps, etc. | (43) Engines & turbines   | (55) LI |
| (2) Crops                | (15) Tobacco               | (30) Paint              | (44) Farm equipment       | (56) C  |
| (3) Forestry & fishing   | (16) Textiles              | (31) Petroleum refining | (45) Constr. & mining eq. | (57) EI |
| (4) Agric. services      | (18) Apparel               | (32) Rubber prod., etc. | (46) Materials hand. eq.  | (58) B  |
| (5) Iron mining          | (20) Wood & products       | (33) Leather tanning    | (47) Metalworking eq.     | (59) M  |
| (6) Nonferrous mining    | (21) Wooden containers     | (34) Shoes              | (48) Special ind. eq.     | (60) A  |
| (7) Coal mining          | (22) Household furniture   | (35) Glass & products   | (49) General ind. eq.     | (61) Tr |
| (8) Petroleum mining     | (23) Office furniture      | (36) Stone & clay prod. | (50) Machine shop prod.   | (62) In |
| (9) Stone & clay mining  | (24) Paper & products      | (37) Iron & steel       | (51) Office & comp. mach. | (63) Ph |
| (10) Chemical mining     | (26) Printing & publishing | (38) Nonferrous metals  | (52) Service ind. mach.   | (64) M  |
| (11) New construction    | (27) Basic chemicals       | (39) Metal containers   | (53) Electrical apparatus | (65) Tr |
| (12) Maintenance constr. | (28) Synthetic materials   | (40) Heating, etc.      | (54) Household appliances | (66) T  |
|                          |                            | (41) Stampings, etc.    |                           | (67) R  |
|                          |                            | (42) Hardware, etc.     |                           |         |

<sup>1</sup> Each point indicates the value of the coefficient for a single 76-order consuming sector in each of two years.

Source: Anne P. Carter, *Structural Change in the American Economy* (Cambridge, Mass.: Harvard Univ. Press, 1970). The projections were done by Arthur D. Little, Inc., for Scientific American, Inc.

Figure 4. DIRECT ALUMINUM COEFFICIENTS FOR 1947, 1958, and EARLY 1970s (Dollars per Dollar in 1958 Prices)<sup>1</sup>



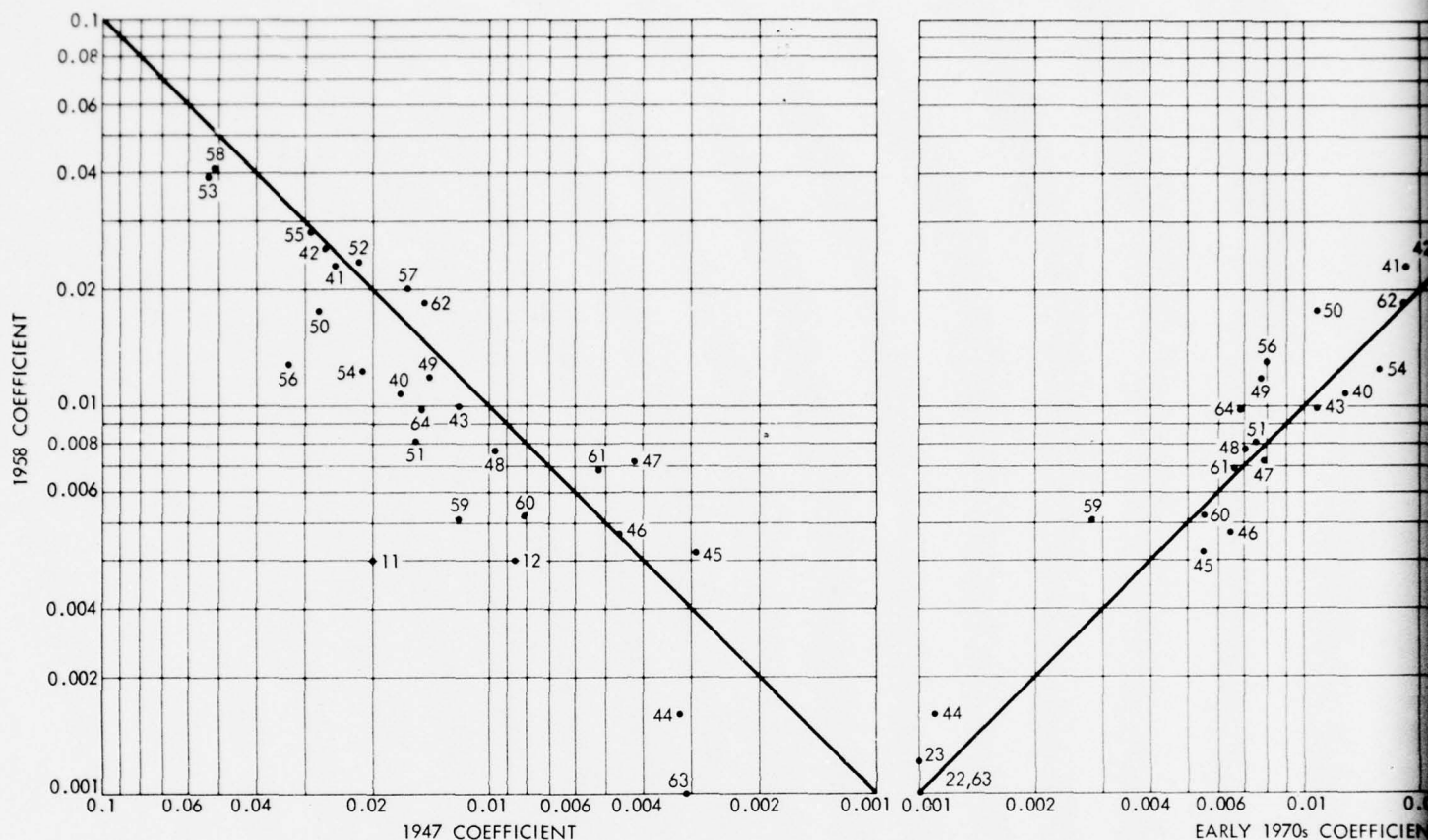
ugs, soaps, etc.	(43) Engines & turbines	(55) Light. & wiring eq.	(68) Utilities
int	(44) Farm equipment	(56) Communication eq.	(69) Trade
roleum refining	(45) Constr. & mining eq.	(57) Electronic compon.	(70) Finance & insurance
ubber prod., etc.	(46) Materials hand. eq.	(58) Batteries, etc.	(71) Real estate & rental
ather tanning	(47) Metalworking eq.	(59) Motor vehicles & eq.	(72) Hotels & pers. serv.
oes	(48) Special ind. eq.	(60) Aircraft	(73) Business services
lass & products	(49) General ind. eq.	(61) Trains, ships, etc.	(74) Research & dev.
one & clay prod.	(50) Machine shop prod.	(62) Instruments, etc.	(75) Auto. repair
on & steel	(51) Office & comp. mach.	(63) Photo. apparatus	(76) Amusements, etc.
onferrous metals	(52) Service ind. mach.	(64) Misc. manufactures	(77) Institutions
etal containers	(53) Electrical apparatus	(65) Transportation	(80) Noncomp. imports
eating, etc.	(54) Household appliances	(66) Telephone	(81) Bus. travel, etc.
ampings, etc.		(67) Radio & tv broad.	(83) Scrap
ardware, etc.			

ter consuming sector in each of two years.

(Cambridge, Mass.: Harvard Univ.  
e, Inc., for Scientific American, Inc.

FOR 1947, 1958, and  
in 1958 Prices)<sup>1</sup>

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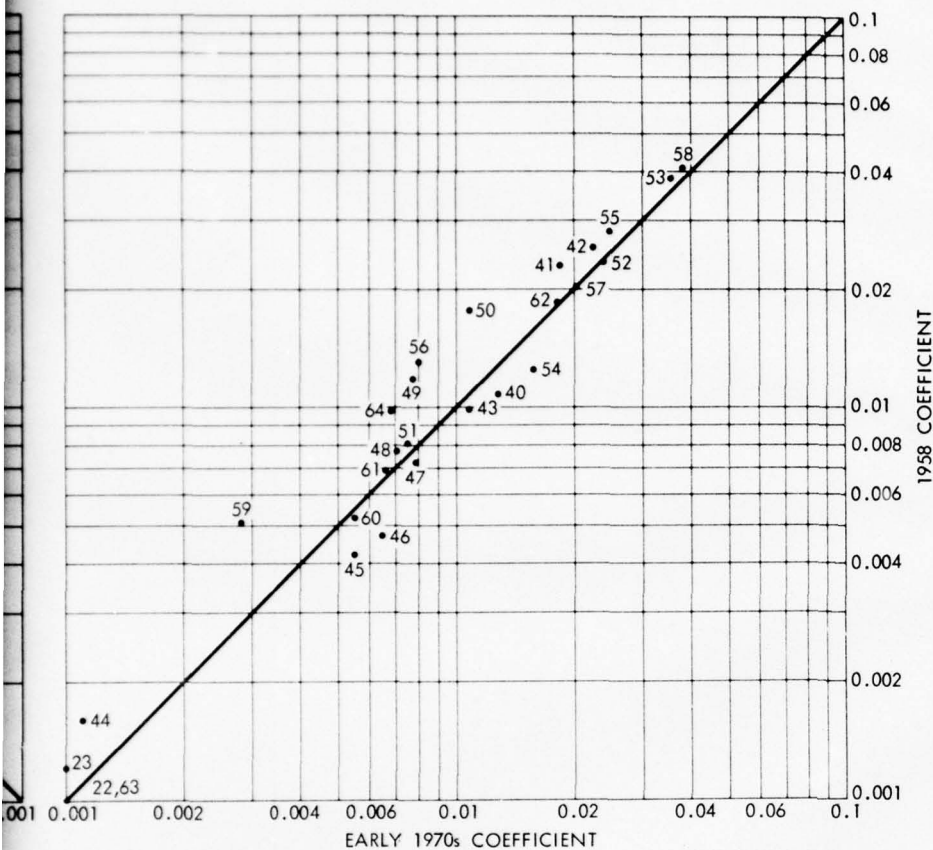
- |                          |                            |                         |                           |                         |
|--------------------------|----------------------------|-------------------------|---------------------------|-------------------------|
| (1) Livestock            | (14) Food                  | (29) Drugs, soaps, etc. | (43) Engines & turbines   | (55) Light. & wiring    |
| (2) Crops                | (15) Tobacco               | (30) Paint              | (44) Farm equipment       | (56) Communication      |
| (3) Forestry & fishing   | (16) Textiles              | (31) Petroleum refining | (45) Constr. & mining eq. | (57) Electronic compo   |
| (4) Agric. services      | (18) Apparel               | (32) Rubber prod., etc. | (46) Materials hand. eq.  | (58) Batteries, etc.    |
| (5) Iron mining          | (20) Wood & products       | (33) Leather tanning    | (47) Metalworking eq.     | (59) Motor vehicles &   |
| (6) Nonferrous mining    | (21) Wooden containers     | (34) Shoes              | (48) Special ind. eq.     | (60) Aircraft           |
| (7) Coal mining          | (22) Household furniture   | (35) Glass & products   | (49) General ind. eq.     | (61) Trains, ships, etc |
| (8) Petroleum mining     | (23) Office furniture      | (36) Stone & clay prod. | (50) Machine shop prod.   | (62) Instruments, etc.  |
| (9) Stone & clay mining  | (24) Paper & products      | (37) Iron & steel       | (51) Office & comp. mach. | (63) Photo. apparatus   |
| (10) Chemical mining     | (26) Printing & publishing | (38) Nonferrous metals  | (52) Service ind. mach.   | (64) Misc. manufactur   |
| (11) New construction    | (27) Basic chemicals       | (39) Metal containers   | (53) Electrical apparatus | (65) Transportation     |
| (12) Maintenance constr. | (28) Synthetic materials   | (40) Heating, etc.      | (54) Household appliances | (66) Telephone          |
|                          |                            | (41) Stampings, etc.    |                           | (67) Radio & tv broad   |
|                          |                            | (42) Hardware, etc.     |                           |                         |

<sup>1</sup> Each point indicates the value of the coefficient for a single 76-order consuming sector in each of two years.

Source: Anne P. Carter, *Structural Change in the American Economy* (Cambridge, Mass.: Harvard Univ. Press, 1970). The projections were done by Arthur D. Little, Inc., for Scientific American, Inc.

Figure 5. DIRECT COPPER COEFFICIENTS FOR 1947, 1958, AND EARLY 1970s (Dollars per Dollar in 1958 Prices)<sup>1</sup>

2



- |                           |                           |                           |
|---------------------------|---------------------------|---------------------------|
| (43) Engines & turbines   | (55) Light. & wiring eq.  | (68) Utilities            |
| (44) Farm equipment       | (56) Communication eq.    | (69) Trade                |
| (45) Constr. & mining eq. | (57) Electronic compon.   | (70) Finance & insurance  |
| (46) Materials hand. eq.  | (58) Batteries, etc.      | (71) Real estate & rental |
| (47) Metalworking eq.     | (59) Motor vehicles & eq. | (72) Hotels & pers. serv. |
| (48) Special ind. eq.     | (60) Aircraft             | (73) Business services    |
| (49) General ind. eq.     | (61) Trains, ships, etc.  | (74) Research & dev.      |
| (50) Machine shop prod.   | (62) Instruments, etc.    | (75) Auto. repair         |
| (51) Office & comp. mach. | (63) Photo. apparatus     | (76) Amusements, etc.     |
| (52) Service ind. mach.   | (64) Misc. manufactures   | (77) Institutions         |
| (53) Electrical apparatus | (65) Transportation       | (80) Noncomp. imports     |
| (54) Household appliances | (66) Telephone            | (81) Bus. travel, etc.    |
|                           | (67) Radio & tv broad.    | (83) Scrap                |

ector in each of two years.

Mass.: Harvard Univ.  
Scientific American, Inc.

1958, AND  
1958 Prices)<sup>1</sup>

or heuristic means are available, based on technological trends or by using new control totals from the National Income Accounts.<sup>1</sup> These might be considered as well as expert review, or in tandem with it.<sup>2</sup>

The delay in dropping the 1958 table (which FPA is now doing) and moving to the 1963 or 1967 tables strikes us as having taken longer than necessary.<sup>3</sup> Although there are problems in using these new tables (deflators and "bridge tables" are not consistently available) it seems feasible that these data could have been used years ago as an aid in improving the I-0 estimates. The data are available and should be applicable to the FPA system with little modification. We would hope that in the future greater effort will be made to keep the model as current as possible.<sup>4</sup>

## 2. Final Demands by Input-Output Sector

The purpose of input-output analysis is to arrive at total output requirements by industry sector given final

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<sup>1</sup>See for example Clopper Almon, Jr., et al., *1985: Inter-Industry Forecasts of the United States* (Lexington, Mass.: Lexington Books, 1975), p. 135; K.J. Arrow and M. Hoffenberg, *A Time Series Analysis of Inter-Industry Demands*, R318 (Santa Monica, CA: RAND Corp., 1958).

<sup>2</sup>Tests indicate that (a) a model updated mechanically does slightly better than one not updated in this way, and (b) judicious expert review improves the model substantially. See the sources cited in United Nations Statistical Office, *Input-Output Tables and Analysis*, Series F, No. 14, Rev. 1 (1973), pp. 74-84.

<sup>3</sup>Both were published in the *Survey of Current Business*; the 1963 table was published in 1969 and the 1967 table in 1974.

<sup>4</sup>The only substantial study of change in the coefficients on an annual basis was undertaken for the Netherlands. The prediction error increased with time if older tables were used; if the table was one year old ( $t=1$ ) the error was about seven percent, and then increased proportionately with the square root of the age of the table ( $t>1$ ). It is not clear how this limited evidence carries over to the U.S., but it is suggestive of the advantages of updating the model. Guido Rey and C.B. Tilanus, "Input-Output Forecasts for the Netherlands, 1949-1958," *Econometrica*, 31 (July 1963), 454-63.

demands. These final demands must be stated by industry sector imposing substantial data requirements. Throughout Chapter II, the total levels of various income components (personal consumption, investment, etc.) were at issue. Input-output requires that we know not only the total, but how this total is divided among industrial sectors. Table 23 presents the form of the data for selected final demand categories and selected industries in 1958.

Table 23. SOME FINAL DEMANDS BY I/O SECTOR FOR SELECTED INDUSTRIES (MILLIONS OF \$ 1958)

I/O Sector	Industry Name	Personal Consumption	Investment	Federal Government Purchases	Total Final Demand
7	Coal Mining	334	--	26	3,944
18	Apparel	17,000	--	455	22,468
22	Household Furniture	3,558	232	33	4,950
37	Primary Iron/Steel	28	--	93	29,161
49	General Ind Machinery	--	1,787	163	2,455
65	Transportation/Warehousing	11,010	989	971	17,329
74	Research & Development	--	--	856	1,106
76	Amusements	3,708	--	13	4,337
84	Households	--	--	24,793	53,235

a. FPA Procedures

Published data corresponding to this format are available from essentially two sources. First, the published input-output tables give these data for personal consumption, investment, inventory changes, federal defense and nondefense purchases, several categories of state and local purchases, and net exports.<sup>1</sup> Secondly, these tables have been supplemented

<sup>1</sup>See, for example, Bureau of Economic Analyses, *Input-Output Structure of the U.S. Economy: 1967*, Vol. I-III (Washington, D.C.: GPO, 19 ).

by periodic publication of more detailed tables (called "bridge" tables) breaking down income categories into finer groupings and examining the change in these groupings over time.<sup>1</sup> These studies tend to follow publication of the input-output tables irregularly and at long intervals;<sup>2</sup> they expand on all uses of income for any published model.

The FPA-chosen model works at a somewhat more detailed level than the level at which data are published by the Bureau of Economic Analysis. Table 24 shows the number of categories into which various income categories can be broken down with each constituent part being translated into industry requirements. The number of these categories from regular published sources are shown, along with the number which has been pieced together from more diverse sources by FPA. The process of piecing these categories together often involved many small (and some less than small) inconsistencies; all of these procedures have been documented at length by FPA.<sup>3</sup>

The data are used by assuming that the percentage of each income category allocated to purchases from each industry sector remains the same over time. Surprisingly, studies by the Bureau of Economic Analysis (BEA) support this assumption for most of the categories they have examined, and the distribution of consumption, investment, and government spending over I-O sectors has, in many cases, remained fairly stable.<sup>4</sup> The

<sup>1</sup>Published in the *Survey of Current Business*, estimates for PCE for 1967 appeared in February 1975; PCE for 1963 appeared in the January 1971 issue; and for 1958, PCE data were published in October 1965. Data on producer durable equipment for 1963 and 1967 appeared in February 1975.

<sup>2</sup>For example, the tables for government expenditures for the 1963 input-output tables were published in the *Survey of Current Business* in May, 1975.

<sup>3</sup>A.A. Schulman, *Demand Impact Transportation Tables*, REG 106, Office of Emergency Preparedness (February 1970).

<sup>4</sup>See, for example, Nancy Simon, "Personal Consumption Expenditures in the 1958 Input-Output Study," *Survey of Current Business* (October 1965), pp. 7-20, 28.

Table 24. NUMBER OF CATEGORIES INTO WHICH INCOME MEASURES ARE BROKEN BY FPA

Income Measure	Possible Categories	From Published Sources	Derived BY FPA
Gross National Product	246	64	182
Personal Consumption	62	28	34
Gross Private Fixed Domestic Investment	45	36	9
Change in Business Inventories	47	1	46
Gross Exports	15	0	15
Gross Imports	17	0	17
Federal Government	45	0	45
State/Local Government	15	0	15
Source: A.A. Schulman, <i>DITT Data Estimates and Input-Output Review</i> , IST-103, Office of Emergency Preparedness (February 1972).			

fact that a few significant changes do occur and that the data are often a decade or more old must qualify any interpretation of these data, but there seems to be little trouble in accepting the data published by BEA as an approximation.

The data derived by FPA must be regarded as weaker on at least two counts: (1) the data base and assumption used are not as strong as those used in studies published by BEA;<sup>1</sup> (2) its derivation is generally unique and its stability over time is unknown. The tables have employed numerous controls to keep the totals in line with both logical constraints and

<sup>1</sup>Inventory changes are, for example, almost strictly judgmental. "Because the lack of solid data requires the application of considerable judgment, there is little point in describing the specific steps taken in estimating the 1966 levels of inventory change activities." Schulman, *DITT*, *op. cit.*, p. 36.

control totals that were available. Because the data are derived at levels more detailed than that normally published, there is little means to test its accuracy directly; however, we have conducted a detailed examination of one sector in the next section.

#### b. Defense Expenditures

Defense needs in a mobilization are significantly quite substantial; the way these needs are projected is important to the value of the model. We attempted to make a detailed assessment of the way these estimates were derived for the defense sector and found it a difficult task. In fact, after a substantial amount of work all we can say is that neither we nor FPA really understand how well their projections of final demand by the Defense Department really work. This is no small criticism in itself. Because of the extremely detailed level at which FPA works in deriving their final demand estimates for Defense, they have exhausted all available *a priori* data and inserted their own judgment in some cases. Consequently, there was little to test the results against. Given the age of the data and the level of understanding of the effects of the procedures used, the estimates are of questionable value.

#### (1) Defense Final Demand by Sector

The FPA input-output model needs defense requirements stated in term of dollars segregated by input-output sector. Unfortunately, Defense Department planners who calculate defense requirements do not plan in terms of input-output sectors, nor should they. Their concerns are with planning, programming, and budgeting expenditures or with the actual procurement and allocation of men and equipment. In the first concern, they think in terms of budget categories; in the second, they deal with numbers of men and different equipment types. Neither

set of categories match up with the FPA input-output sectors, although all cover the same thing--defense requirements for goods and services. The problem is to transform requirements from categories meaningful to the defense planners into the FPA input-output sectors so that the computer model can do its job.

The first part of the problem is to figure out what these categories should be. There appear to be four main objectives which often conflict:

(1) *The categories should be familiar to defense planners.*

(2) *The categories should be detailed enough so that the purchase pattern of a dollar expended in any one of these categories does not change significantly in a rapid shift from peace to war.* In general, the total defense purchase pattern will shift as the military's mission shifts from training to combat and the nature of the conflict becomes known. A nuclear war would have different requirements than a conventional war, as would a strategic and a tactical war. The mix of land, sea, and air conflict would also affect the pattern of equipment requirements. Technological change is another factor affecting the purchase pattern, but in the short-run; this would be a secondary effect compared to changes in the nature of defense demand.

(3) *The categories should be as broad as possible to ease the job of the defense planner.* The defense planner is given a very general scenario and is asked to come up with defense requirements in terms of dollar expenditures in each category. The more detailed these categories are, the more work he must do.

(4) *The categories should be such that the coefficients which distribute dollars over the input-output sectors can be estimated from available data.*

The current FPA projections are based on defense expenditures split over 30 categories, called "activities." These categories are listed in Table 25. They correspond to budget titles, with Procurement split into 26 groups corresponding to the type of equipment procured.<sup>1</sup> Viewed against the objective stated above, they are probably a good compromise. Some advantage might be gained by making the categories correspond to budget programs (listed in Table 26) rather than budget titles. Budget programs group defense goods and services by function/mission and, conceptually, should be easier to relate to a scenario defined in terms of a mission. Viewing defense requirements by way of the current FPA activities might present problems as "Operations and Maintenance" dollars do not distinguish between Strategic and General Purpose Forces, nor does "Missiles" distinguish between those that can be used in a conventional war and those that cannot. If the scenario called for fighting a conventional war with general purpose forces, then the purchase patterns associated with the FPA activities might lead to conceptual distortions.

Once the defense categories have been determined, the second part of the problem is to estimate the coefficients that represent the purchase pattern for each category. As an example, suppose there are two defense categories--combat unit requirements and support unit requirements--and the three input-output sectors the example used in the beginning of this chapter. The defense planners estimate dollar requirements:

$S_1$  = dollars required by combat units.

$S_2$  = dollars required by support units.

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<sup>1</sup>Chapter II also discusses these sectors and the sums of money for each sector.

Table 25. FPA DEFENSE ACTIVITIES

1. Military Personnel
2. Operations and Maintenance
3. Research and Development
4. Family Housing
5. Military Construction
6. Civil Defense
7. Aircraft
8. Army Missiles
9. Navy Missiles
10. Air Force Missiles
11. Marine Corps Missiles
12. Ships - Building and Conversion
13. Ship Support
14. Army Electronic & Communications
15. Navy Electronics & Communications
16. Air Force Electronic Communications
18. Army Ammunition
19. Navy Ammunition
20. Air Force Ammunition
21. Marine Corps Ammunition
22. Army Weapons and Combat Vehicles
23. Army Tactical Support Vehicles
24. Army Support Equipment & Production Base
25. Navy Civil Engineer Support Equipment
27. Marine Support Vehicles
28. Marine Engineer & Other Equipment
29. Air Force Vehicular Equipment
30. Air Force, Other Base Maintenance & Support Equipment

Table 26. DEFENSE BUDGET PROGRAMS

<u>Combat Units</u>	
BP1.	Strategic Forces
BP2.	General Purpose Forces
<u>Support Units</u>	
BP3.	Intelligence and Communications
BP4.	Airlift and Sealift
BP7.	Central Supply and Maintenance
BP8.	Training, Medical, Other Personnel Activities
BP9.	Administration and Associated Activities
<u>Other</u>	
BP5.	Guard and Reserve Forces
BP6.	Research and Development
BP10.	Support of Other Nations

The coefficients representing the purchase patterns are of the following form:

- $a_{11}$  = proportion spent on aircraft by combat units.
- $a_{12}$  = proportion spent on steel by combat units.
- $a_{13}$  = proportion spent on labor by combat units.
- $a_{21}$  = proportion spent on aircraft by support units.
- $a_{22}$  = proportion spent on steel by support units.
- $a_{23}$  = proportion spent on labor by support units.

Total defense final demand is computed as follows:

$$s_1 a_{11} + s_2 a_{21} = f_1 = \text{final demand for aircraft.}$$

$$s_1 a_{12} + s_2 a_{22} = f_2 = \text{final demand for steel.}$$

$$s_1 a_{13} + s_2 a_{23} = f_3 = \text{final demand for labor.}$$

The most direct method for estimating the purchase pattern coefficients ( $a_{ij}$ ) is to examine how defense dollars, grouped by category, were spent in recent years buying goods and services grouped by input-output sector. Unfortunately, the last time such data were collected was for an unpublished study done by the Research Analysis Corporation based on an analysis of 1963 defense expenditures.<sup>1</sup> Besides being old, the data had the added disadvantage of not being entirely consistent with either the defense categories or the input-output sectors and, thus, forced FPA into some guesswork of unknown value.

## (2) Updating the Coefficients

There are two sources of published data that FPA used as a guide in updating their coefficients. Both yield estimates of the historical defense final demand vector ( $f_i$ ). One is a reliable estimate, yet relatively out-of-date; the other is subject to greater error, yet relatively current.

The reliable estimate is the defense purchases vector published by the Bureau of Economic Analysis in their input-output studies.<sup>2</sup> Unfortunately, the most recent study is based on data that are nine years old, yet it is more current than the 1963 RAC report. In order to use the data, one must first estimate the defense expenditures in that year ( $s_i$ ). At this point ( $f_i$ ) and ( $s_i$ ) are known and the defense final demand equations

$$\sum_i s_i a_{ij} = f_j$$

<sup>1</sup>We have not seen this study, as neither FPA nor RAC can find it; it is cited by Schulman, *DITT*, *op. cit.*

<sup>2</sup>The most recent study is *Input-Output Structure of the U.S. Economy: 1967*, Bureau of Economic Analysis (1974).

constrain the purchase pattern coefficients ( $a_{ij}$ ). Unfortunately, there are more unknowns, ( $a_{ij}$ ), than equations, and one needs additional information in order to solve for ( $a_{ij}$ ). In the example above there were six purchase pattern coefficients and five constraining equations--three final demand equations plus the two equations constraining the coefficients to be proportions.

$$a_{11} + a_{12} + a_{13} = 1$$

$$a_{21} + a_{22} + a_{23} = 1$$

The equations could be solved if additional information were available--e.g., the value of one of the coefficients or the relationship between two or more of the coefficients. For the full-sized problem, the difference between the number of unknowns and equations is much greater and, thus, the need for additional information and/or educated guesses is much greater.<sup>1</sup>

Appendix A presents the current set of defense purchase pattern coefficients, also called defense factor files. FPA is in the process of adjusting them in the manner described above so they will be consistent with the 1967 defense purchase vector published by BEA. The coefficients are displayed here since they are not published elsewhere. Defense planners may find it useful to see how their dollars are assumed to be spent.

The other source of published data used by FPA is the Bureau of the Census MA-175 survey on defense shipments. It is a survey of certain four-digit SIC code industries and

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<sup>1</sup>FPA presumably uses a balancing procedure such as the well-known rAS method used to update input-output coefficients, and which empirical evidence indicates works well for input-output tables. Its value for this application is entirely speculative.

reports shipments to the Department of Defense. Its good feature is that it is a yearly survey and is relatively current; survey results through 1973 have been published. However, MA-175 survey data are limited: (1) The survey covers all the four-digit SIC code industries that define the FPA input-output sectors *for only five sectors*. (2) The survey totals are in purchaser's prices, whereas the totals needed by FPA are defined in producer's prices. Consequently transportation, warehousing, and retail trade costs must be subtracted from survey totals before they can be used. (3) The survey does not explicitly cover small firms, but uses an estimate of their contribution to the totals. FPA uses the MA-175 survey data only as a gross check. Due to the uncertainties associated with the data, we feel that this limited usage is appropriate.

We feel that FPA has used existing data in a reasonable way to estimate the defense purchase pattern coefficients. On the other hand, confidence in the coefficients is greatly weakened by the age of the data used in estimating the coefficients and by the amount of guesswork involved in the estimation process itself. Even with the obvious weaknesses of the MA-175 survey data, we felt that a comparison with FPA baseline projections might show trends over time and provide some test of confidence in the data. Table 27 represents defense requirements based on the MA-175 survey data for the five input-output sectors which were fully covered. The survey data were published in current dollars, then deflated to 1958 constant dollars, using INFORUM sector deflators, so that the totals could be compared with FPA projections. To convert the survey data to producer's prices, the average proportion spent by defense on transportation, warehousing, and retail trade was calculated based on the BEA 1967 defense purchases vector. This proportion was then subtracted from each MA-175 survey total. Table 28 lists defense requirements projected by the

Table 27. DEFENSE REQUIREMENTS BASED ON MA-175 SURVEY DATA  
(MILLIONS OF 1958 DOLLARS)

Number	I/O Sector Name	1965	1966	1967	1968	1969	1970	1971	1972
13	Ordnance/ Accessories	2132.7	3105.0	4978.2	6471.9	6612.5	4720.3	3179.3	3297.8
43	Engines/ Turbines	245.0	345.9	412.9	325.6	336.5	276.1	252.9	150.8
57	Electronic Components/ Accessories	194.4	240.8	326.2	358.3	335.4	259.9	232.8	332.7
60	Aircraft/ Parts	8018.6	9342.8	11132.5	10710.1	9930.1	8780.5	7134.9	5869.6
63	Optical/ Photographic Equipment	222.3	348.7	361.2	427.0	208.7	114.7	121.0	176.3

Table 28. DEFENSE REQUIREMENTS PROJECTED BY FPA  
(MILLIONS OF 1958 DOLLARS)

Number	I/O Sector Name	1965	1966	1967	1968	1969	1970	1971	1972
13	Ordnance/ Accessories	3256.0	4150.7	5911.4	6894.3	6838.1	5498.4	4199.9	4362.3
43	Engines/ Turbines	229.5	218.3	246.6	261.2	270.3	245.1	204.1	248.4
57	Electronic Components/ Accessories	343.0	378.2	433.2	449.2	420.5	377.3	320.3	372.5
60	Aircraft/ Parts	6287.2	7710.9	9253.7	9627.6	8246.8	6990.5	5684.1	5667.5
63	Optical/ Photographic Equipment	193.2	216.3	360.5	388.3	337.8	277.1	207.6	222.1

FPA model. They were generated by passing FPA estimates of defense expenditures through the current purchase pattern coefficients (defense factor files). Table 29 is the percent difference between the survey totals and the FPA projections, and Table 30 compares the survey totals and FPA projections

Table 29. PERCENT DIFFERENCE =  $100 \times ((MA-175) - (FPA) / (MA-175))$

Number	I/O Sector Name	1965	1966	1967	1968	1969	1970	1971	1972
13	Ordnance/ Accessories	-52.7	-33.7	-18.7	- 6.5	- 3.4	-16.5	-32.1	-32.3
43	Engines/ Turbines	6.3	36.9	40.3	19.8	19.7	11.2	19.3	-64.7
57	Electronic Components/ Accessories	-76.4	-57.1	-32.8	-25.4	-25.4	-45.2	-37.6	-12.0
60	Aircraft/ Parts	21.6	17.5	16.9	10.2	17.0	20.4	20.3	3.4
63	Optical/ Photographic Equipment	13.1	38.0	0.2	9.1	-61.9	-141.6	-71.6	-26.0

with the BEA defense purchases vector for 1967. The most notable feature of both Table 27 and 28 is the increase in requirements generated by the Vietnam War.

The most surprising result was the comparison presented by Table 29. Of the three estimates of defense demand in 1967, the BEA data appear the most credible as they are based on a more complete census of manufacturers. Using the BEA data as a base, the MA-175 survey totals shows greater variation than the FPA projections. At least for 1967, the FPA projections appear more accurate for these five sectors. It should also be noted that there are significant differences between the FPA projections and the BEA data.

Viewing Table 29 in the light of the comparison of Table 30, it is appropriate to look only for large shifts over time in the percent differences. From this viewpoint, sectors 43 and 60 might bear watching as, over time, FPA went from underestimating relative to the MA-175 data to overestimating. Yet it should be noted that for both these sectors, defense

contributed a relatively small portion of total demand, and errors here will affect the total by a smaller amount. Two lessons that *can* be drawn from these tables are that the MA-175 survey data should be used only with great care, and that the FPA data cannot be shown to be in error in a comparison with MA-175 survey totals. We feel that, based on the fact that the quality of the data is unknown and probably untestable against published data, there is a need for tracing current defense expenditures and using this data to directly re-estimate the defense purchase pattern coefficients.

Table 30. A COMPARISON OF THE MA-175 DATA AND THE FPA PROJECTIONS AGAINST THE BEA FINAL DEMAND VECTOR  
(MILLIONS OF 1958 DOLLARS)

Number	I/O Sector Name	BEA 1967 Defense Final Demand Vector	1967 Defense Requirements Based on the MA-175 Survey	1967 Defense Requirements Based on FPA Projections
13	Ordnance/ Accessories	5608.1	4978.2 ( 11.2) <sup>a</sup>	5911.4 (- 5.4)
43	Engines/ Turbines	345.6	412.9 (-19.5)	246.6 ( 28.6)
57	Electronic Components/ Accessories	638.7	326.2 ( 48.9)	433.2 ( 32.2)
60	Aircraft/ Parts	7008.8	11132.5 (-58.8)	9253.7 (-32.0)
63	Optical/ Photograph Equipment	314.7	361.2 (-14.8)	360.5 (-14.6)

<sup>a</sup>The numbers in parentheses represent percent differences relative to the BEA data.

### C. TOTAL OUTPUT PROJECTIONS

Given final demands by sector, it is possible to solve (as in the example above) for the total output required to support these final demands. The computational procedure determines the intermediate requirements for each industry once final demands are specified. One way to judge the accuracy of the input-output analysis is to gauge the accuracy of the overall results. Because of the possibility of unfounded assumptions cancelling each other in such a test (but later failing to cancel in actual application), it is not a fool-proof guide to the methodology's accuracy. Table 31 compares the projections of shipments by industry sector in 1970 using the FPA model<sup>1</sup> to the estimates of shipments from the Survey of Manufacturers for the same year.<sup>2</sup> The ratio of the FPA estimate to the survey data is also shown, indicating a percentage error in the FPA projection with a median value of just over four percent across the 52 sectors. The Census data is itself an estimate and each sector probably has an error of three (in a few cases maybe four) percent resulting from the survey methods used. A small but significant error exceeding these survey errors is introduced into more than half the sectors involved by using FPA projections.<sup>3</sup>

Although consolation can be taken from the small size of these errors, their frequency implies some caution must be

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<sup>1</sup>Schulman, *DITT Data Estimates*, op. cit., pp. 56-57. This source also shows 1968 data which compares slightly more favorably to published data.

<sup>2</sup>Shipment data are from U.S. Bureau of the Census, Annual Survey of Manufactures: 1970, *Industry Profiles*, M 70(AS)-10 (Washington, D.C.: GPO, 1973).

<sup>3</sup>The error figure for the Census data is taken from a casual examination of the errors claimed in *General Statistics for Industry Groups and Industries*, M71 (AS)-1 (Washington, D.C.: GPO, 1973). Errors at the four digit level rarely exceed two percent for large sectors, but may be much higher for small sectors. The average error (assuming no covariance) is probably well below four percent in most sectors.

Table 31. THE 1970 VALUE OF SHIPMENTS FOR MANUFACTURES BY  
FPA PROJECTION AND BY CENSUS BUREAU ESTIMATES  
(\$ million)

I-O SECTOR NO.	SECTOR TITLE	FPA ESTIMATE	CENSUS ESTIMATE	RATIO FPA TO CENSUS
	TOTAL MANUFACTURING	642,526	634,332	101.3
13	Ordinance & accessories	9,129	8,143	112.1
14	Food & kindred products	99,909	98,533	101.4
15	Tobacco manufactures	5,795	5,350	108.3
16	Broad & narrow fabrics, yarn & thread mills	12,974	12,240	106.0
17	Miscellaneous textile goods & floor coverings	4,718	4,792	98.5
18	Apparel	27,583	25,049	110.1
19	Miscellaneous fabricated textile products	4,129	4,211	98.1
20	Lumber & wood products, except containers	11,131	12,596	88.4
21	Wooden containers	486	449	108.2
22	Household furniture	5,861	5,997	97.7
23	Other furniture & fixtures	2,891	3,078	93.9
24	Paper & allied products, except containers	18,011	20,941	86.0
25	Paperboard containers & boxes	7,032	6,938	101.4
26	Printing & publishing	26,365	25,757	102.4
27	Chemicals & selected chemical products	22,445	22,446	100.0
28	Plastics & synthetic materials	8,683	8,601	101.0
29	Drugs, cleaning & toilet preparations	14,262	14,926	95.6
30	Paints & allied products	3,222	3,383	95.2
31	Petroleum refining & related industries	25,243	24,883	101.4
32	Rubber & miscellaneous plastic products	15,467	15,471	100.0
33	Leather tanning & industrial leather products	944	844	111.2
34	Footwear & other leather products	4,960	4,444	111.6
35	Glass & glass products	4,526	4,533	100.0
36	Stone & clay products	12,317	12,228	100.7
37	Primary iron & steel manufacturing	33,750	31,655	106.6
38	Primary nonferrous metals manufacturing	21,960	21,856	100.4
39	Metal containers	4,328	4,303	100.6
40	Heating, plumbing & structural metal products	13,321	14,063	94.1
41	Stampings, screw machine products & bolts	9,898	9,797	101.0
42	Other fabricated metal products	12,554	11,589	108.3
43	Engines & turbines	3,878	4,481	86.5
44	Farm machinery & equipment	4,328	4,332	100.0
45	Construction, mining & oil field machinery	6,528	6,533	100.0
46	Materials handling machinery & equipment	2,699	2,767	97.5
47	Metalworking machinery & equipment	1,667	7,513	102.0
48	Special industry machinery & equipment	6,286	5,392	116.6
49	General industrial machinery & equipment	7,317	7,620	96.0
50	Machine shop products	3,578	3,976	90.0
51	Office, computing & accounting machines	7,432	7,693	96.6
52	Service industry machines	5,339	5,773	92.5
53	Electric industrial equipment & apparatus	9,709	9,477	102.4
54	Household appliances	6,060	6,033	100.4
55	Electric lighting & wiring equipment	4,440	4,687	94.7
56	Radio, television & communication equipment	16,026	17,427	92.0
57	Electronic components & accessories	6,992	7,283	96.0
58	Misc. electrical machinery, equipment & supplies	3,200	3,513	91.1
59	Motor vehicles & equipment	48,633	42,943	113.3
60	Aircraft & parts	19,761	20,527	96.3
61	Other transportation equipment	7,686	9,116	84.3
62	Scientific & controlling instruments	6,055	6,418	94.3
63	Optical, ophthalmic & photographic equipment	5,129	5,364	95.6
64	Miscellaneous manufacturing	9,889	9,743	101.5

Sources: DITT Data Estimates, op. cit., pp. 56-57; Industry Profiles, op. cit.; Input-Output Structure of the U.S., op. cit.

exercised in accepting the results. The estimates are based on untestable assumptions in some cases, and on weak data which are difficult to test. A small but significant potential for error is known to exist in the projections. Certainly the estimates should be regularly and rigorously tested whenever possible and the transformations regularly updated. As implemented by FPA, input-output is far from a perfect tool and it requires attention and constant updating to keep it credible.

#### D. CONCLUSIONS

The major conclusions to be drawn from this chapter are that input-output analysis is a key segment of FPA's material projections; that FPA's procedures are broadly correct and consistently applied; and that their data requirements make their results uncertain. Compared to the potential for error which might be introduced by the lack of validity of the assumed scenario or (as we will see in Chapter V) the error introduced by data on raw materials, the error introduced by input-output seems comparatively small.

We think more care can and should be used in keeping the model up-to-date and consistent.

- The input-output table needs to be updated regularly and with greater attention than in the past. A wide range of studies indicate the need for such updating. Mechanical methods are simple and inexpensive, and FPA has access to a wide range of governmental expertise at the Commerce and the Interior Departments that can assist in this effort.
- The composition of final demand is derived by assumptions that are untestable and on data that are old or of dubious value. A detailed analysis of the DoD requirements assumed by FPA reveal that they are particularly susceptible to such criticism. The age and uncertainty associated with these tables, combined with the importance of DoD requirements in a mobilization, make a complete review important. We have no assurance that small errors apparent in "backcasting" will not be blown up with greatly increased demand for military equipment.

- The errors in output projections averaged four to five percent in absolute terms for 1970. These, encouragingly, are small.

Recognizing that FPA has limited resources, we suggest a closer liaison with groups making similar efforts would be worthwhile. The INFORUM model at the University of Maryland<sup>1</sup> makes a substantial effort each year to update its input-output table, to construct final demand by sector, and to predict total output. The INFORUM tables are updated mechanically and by expert review. A wide range of governmental and industrial clients use the model and often provide detailed sectoral data. Final demands are projected using a wide range of econometric techniques. FPA's model and procedures might be preferred for actually computing stockpile requirements, but comparing the basic data used by both models, by contrasting the assumptions and procedures, and by examining the differences in the estimates of the models, might force a continued review of both data and procedures on FPA. Having their results continually challenged and having a similar basis for comparison might assure better efforts at keeping up-to-date.

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<sup>1</sup>Almon, et al., *op. cit.*

## Chapter IV

### THE ACCURACY OF THE MODEL

The FPA model is concerned with individual materials--cobalt, titanium, beryl ores, etc. The projections obtained in Chapter III using the input-output model are for broad industry groups which collectively describe the entire economy; these sectors are much larger in terms of sales volume than the often small, specialized markets for materials to be stockpiled. The FPA model combines the input-output projections with "material skirt" data. The result is a series of projections of requirements for individual materials.

The purpose of this chapter is to assess the accuracy of the model at the materials level. In a sense these projections are the bottom-line in a long sequence of forecasting procedures, and the errors at the materials level are important in assessing how well the entire process works and how the results are to be used. To assess the accuracy of the FPA model, we have tried to gauge errors in the model through the use of "backcasts" and forecasts. Backcasts by FPA have been compared with historical data from published sources, and with projections by the INFORUM model over this same historical period. Forecasts were developed for a hypothetical mobilization beginning in 1978, which conforms broadly to past scenarios used for stockpile planning. Historical data are not available to test the adequacy of forecasts; but we contrasted these forecasts with those of INFORUM, and then compared them with a "direct" projection of titanium requirements. (By "direct" we simply mean that material use (for titanium sponge only) was geared directly

to the expanded production of military materiel (mostly aircraft); the intermediate conversion to dollars and the input-output table could be partly skipped.)

INFORUM--an input-output model--was chosen as a contrast because it is widely known and extensively used.<sup>1</sup> It provides numerous procedural contrasts to the FPA model, but it can be adapted to provide projections based on the same data. It is probably better maintained and theoretically more sound than FPA's model, but it is also more difficult to apply to this particular problem.

Taken together, the comparisons here provide a series of useful contrasts: (1) the backcasts allow us to compare two structurally *similar* models (FPA's and INFORUM--similar given their common basis in input-output analysis) with historical data on materials usage; (2) the forecasts compare the results of structurally similar models expected to perform in similar ways; and (3) the direct projection is a comparison of *different* models working on the same forecasts. The fact that all three methods provide broadly similar responses is encouraging in assessing the accuracy of the FPA model.

#### A. USE OF THE MATERIAL SKIRT

The input-output analysis described in Chapter III takes account of direct and indirect requirements, and provides an estimate of the total output ( $Q_i$ ) of each sector required to support the mobilization. The "skirt" for a particular material describes the use of this material in each industry sector defined as

$$C_i = \frac{\text{quantity of material}}{\text{dollars of output}}$$

where there are  $i = 1, \dots, n$  sectors or industries. Many of these will be zero values for a given material; for example,

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<sup>1</sup>Almon, et al., *op. cit.*

titanium is used in the production of aircraft and industrial machinery and it has only two non-zero values. Total use of the material is projected by combining the "skirt" with the input-output projections. The use of the material in the (i)th sector is  $M_i = C_i Q_i$ , and the total use of the material by all  $i = 1, \dots, n$  sectors or industries is:

$$M = \sum_{i=1}^n M_i = \sum_{i=1}^n C_i Q_i .$$

After adjustment for substitution and possible technological trends, this figure is taken as the requirement for materials. It is compared to estimates of the availability of materials to determine the stockpile objective.

#### B. BACKCASTS 1970-1975

There are three major areas in which errors can enter the *forecasts* of material utilization: (1) the statement of "uses of income;" (2) the estimation of total output using input-output analysis; and (3) in the materials skirt data. For purposes of *backcasting*, the uses of income are known exactly from published sources.<sup>1</sup> Errors uncovered here stem only from input-output results and the skirt data. It is almost certain that estimates associated with a future mobilization and the associated uncertainty about future uses of income will produce results more prone to error. These backcasts are made under very favorable circumstances compared to the forecasts, and the errors found here are best interpreted as a lower bound on the errors produced by the model.

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<sup>1</sup>The National Income and Product Accounts published by the Department of Commerce.

## 1. INFORUM and FPA Backcasts

Fourteen materials were chosen for the backcasts made over the period 1970-1975. The choice of materials was somewhat arbitrary, but they were chosen on such criteria as direct military interest (titanium, beryl), specialized use (feathers and down for cold weather gear), or basic use throughout the economy (lead and zinc). Beginning with published data on the uses of income, both the FPA model and INFORUM produced estimates of the use of these materials. These models derived the bill of goods in different ways, used different input-output tables, and computed the skirt data slightly differently. FPA used a linear trend or mean value for the skirt, and sometimes adjusted the skirt based on extraneous data; INFORUM estimated a curvilinear trend (a logistic curve) with no further adjustments.

Table 32 shows the results of the backcast. Each yearly section compares the FPA and INFORUM projections with data from published sources,<sup>1</sup> or with data solicited from commodity experts in the Interior and the Commerce Departments. The average absolute percent error for each year shows the absolute error for each material averaged across all years. The FPA and INFORUM models produced very similar results. Of 78 comparisons of errors, the two models produced errors with the same sign 54 times; i.e., the direction of the error was the same nearly 70 percent of the time. The average absolute errors averaged over all years show very similar magnitudes for almost all the materials. The FPA model performs slightly better than INFORUM, perhaps reflecting FPA's use of extraneous data to adjust the skirt, which was not used in INFORUM. On the whole it must be concluded that the models produce very similar projections. This similarity suggests a certain basic robustness to the forecasting process which is encouraging in applying these kinds of models; despite

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<sup>1</sup>Bureau of Mines, *Commodity Data Summaries 1976* (Washington, D.C.: GPO, 1976).

Table 32. BACKCASTS WITH INFORUM AND THE FPA MODEL:  
1970-75

Material	1970			1971			1972			1973			1974			1975			Absolute Average Percent Error	
	Published	Percent Error		Published	Percent Error		Published	Percent Error		Published	Percent Error		Published	Percent Error		Published	Percent Error		INFORUM	FPA
		INFORUM	FPA		INFORUM	FPA		INFORUM	FPA		INFORUM	FPA		INFORUM	FPA		INFORUM	FPA		
Antimony st	32,565.0	-5.4	-6.7	31,290.0	-9.0	-11.7	34,865.0	-7.2	-5.4	44,675.0	15.0	8.9	41,041.0	12.3	7.6	36,000.0	2.0	11.1	8.5	8.6
Beryl st	10,919.0	-2.8	-2.4	11,994.0	-3.7	10.0	12,978.0	-4.5	-5.7	8,595.0	-59.7	-39.9	NA	NA	NA	NA	NA	NA	17.6	14.5
Bismuth th lbs	2,210.0	0.2	-2.2	1,649.0	-30.4	-34.7	2,220.0	-1.4	-5.2	2,906.0	17.6	13.5	2,284.0	2.1	-4.6	1,241.0	-74.8	-75.6	21.1	22.6
Cadmium th lbs	10,231.0	-31.2	-29.5	12,182.0	-14.2	-9.4	14,276.0	-3.5	-0.5	12,456.0	-24.7	-19.5	12,100.0	-27.5	-20.9	9,200.0	-70.9	-49.4	28.7	21.5
Feathers/Down th lbs	8,508.0	12.1	-14.0	7,974.0	11.0	-13.6	9,128.0	9.9	11.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	11.0	12.9
Lead th st	1,362.0	1.7	3.7	1,432.1	6.3	5.2	1,485.1	1.0	2.4	1,541.0	1.7	-7.0	1,599.0	8.1	1.4	1,226.0	-18.8	-11.5	6.3	5.2
Nickel st	159,369.0	7.5	7.4	128,797.0	-12.8	-11.4	160,773.0	2.6	1.5	197,723.0	14.5	11.8	208,409.0	22.1	20.1	145,000.0	-11.7	1.1	11.9	8.9
Opium th lbs	450,000.0	8.7	4.7	364,000.0	-12.4	-20.3	557,000.0	20.8	17.0	608,800.0	24.5	19.0	729,300.0	41.3	34.0	800,000.0	49.3	38.2	26.2	22.2
Platinum th troy oz	566.0	2.9	9.1	432.0	-30.5	-16.9	542.0	-13.3	0.4	659.0	-2.5	11.2	944.0	28.6	40.7	NA	NA	NA	15.6	15.7
Quinine th avoird oz	1,711.0	-0.1	6.6	1,745.0	-4.2	6.6	1,732.0	-21.2	0.9	2,216.0	-5.6	17.1	2,055.0	-13.6	12.7	1,719.0	-37.9	-7.2	13.8	8.5
Rutile st	254,076.0	-6.9	-3.0	283,566.0	-10.2	6.4	300,694.0	-13.0	-2.2	277,000.0	-26.4	-1.1	292,000.0	-24.5	2.4	230,000.0	-64.2	-23.4	24.2	6.4
Silver th troy oz	166,083.0	4.7	-15.5	161,729.0	7.4	-10.5	161,940.0	10.0	-6.0	196,800.0	18.9	10.5	178,000.0	5.9	5.7	156,200.0	-7.6	3.1	9.1	8.6
Tantalum th lbs	2,199.0	11.2	20.2	2,241.0	8.1	-15.6	2,475.0	5.1	-14.4	1,728.0	-49.4	-2.4	2,425.0	-13.2	27.5	1,500.0	-95.0	-2.4	30.3	13.8
Titanium Sponge st	16,414.0	-6.6	4.6	12,145.0	-30.3	-17.6	13,068.0	-17.6	-25.0	20,173.0	11.3	11.0	26,896.0	33.1	30.5	17,500.0	-11.3	-7.7	12.9	16.1

Notes: Percent Error =  $\frac{[(\text{Published} - \text{Predicted}) / \text{Published}] \times 100}{}$

Average Absolute Percent Error =  $\frac{\sum |\text{Percent Error}| / \text{No. of Years Observed}}{}$

NA = Not Available

the many fundamental differences between them, the models took the same data and derived similar results.

## 2. Disaggregating the Errors

Because uses of income are known in these backcasts, the only sources of error are the output projections ( $Q_i$ ) and the consumption ratios in the skirt ( $C_i$ ). It is insightful to partition the error in the forecasts into separate parts attributable to each source; we will see that the skirt data are responsible for a major part of the overall error in the projections. Indeed, improving the skirt data offers far more promise of upgrading the quality of the forecasts than improving the input-output tables and projections of final demand.

The skirt projection was expressed above as

$$M = \sum_{i=1}^n C_i Q_i .$$

Suppose that  $C_i^*$ ,  $Q_i^*$  are the values that would make the forecast perfect.

$$C_i = (1-e_i)C_i^*$$

$$Q_i = (1-E_i)Q_i^* .$$

The errors  $e_i$ ,  $E_i$  are percentage errors in the skirt data and the output projections, respectively. Table 33 shows these percentage errors for each material in 1970.<sup>1</sup> These are absolute values averaged across all sectors entering the skirt

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<sup>1</sup>The ratio  $(1-E_i) = Q_i/Q_i^*$  was computed in Table 25, Chapter III. The ratio of actual to predicted material use ( $C_i Q_i / C_i^* Q_i^*$ ) in 1970 is the product  $(1-e_i)(1-E_i)$ ; the skirt error is computed by dividing this product by  $Q_i/Q_i^*$ . The error is decomposed for each sector, and Table 33 shows the average absolute value of the error across all non-zero sectors for each material.

Table 33. DECOMPOSITION OF ERRORS IN  
THE 1970 BACKCAST<sup>a</sup>

Material Stockpiled	Material	Output	Skirt
Antimony	14.0	5.2	15.2
Beryl	16.5	5.0	9.4
Bismuth	6.1	3.7	6.8
Cadmium	19.4	5.1	20.7
Feathers & Down	11.0	1.9	9.3
Lead	7.1	5.3	9.7
Nickel	4.5	5.6	7.3
Opium	20.9	4.4	17.2
Platinum	15.5	3.4	29.2
Quinine	17.3	1.9	18.1
Rutile	18.5	3.0	18.4
Silver	17.0	5.5	26.8
Tantalum	6.1	2.4	6.4
Titanium	19.3	3.9	24.0

<sup>a</sup>These are the averages across sectors for 1970. The averages not weighted by sector size and they are in absolute value.

calculation, and they are unweighted by sector size. The first column shows the error in projected material use, the second column shows the error in the output projection, column three shows the error in the skirt data. The skirt data exhibit errors larger in every case than the output errors; in many cases three to six times the size of the output would seem to offer a greater opportunity for improving the forecasting abilities of the model than improvement in the output projections. The output errors are largely associated with the input-output procedures, and, as we saw in Chapter III, these errors remain well behaved. The skirt data exhibits errors which are larger in every case than

the output errors, and in many cases the errors are three to six times the output error. Improvement in the "skirt" projections would seem to offer a greater opportunity for increasing the forecasting potential of the model than improving the output projections. Continued review of the data input by experts in each of the materials markets would seem critical to improving accuracy.

### C. FORECASTS 1978-1980

#### 1. FPA and INFORUM Projections

To test whether both the FPA and INFORUM models responded similarly to a substantial shock, such as a major mobilization, both models were asked to project materiel requirements based on the uses of income used to describe a mobilization in Table 34.<sup>1</sup> The mobilization is hypothetical, but corresponds in magnitude and composition to that used by FPA for actual projections of wartime conditions for past projections.

Table 35 summarizes the results of these wartime forecasts. The models perform in a very similar manner, and the magnitude of the difference between projections is in line with the size of the errors observed in backcasting, with about half the difference being less than 10 percent. The INFORUM projections tended to be consistently larger than those of FPA, with the difference apparently depending on the differences in the composition of final demand in the two models.

The models respond to the mobilization in an encouragingly similar manner. The reader should be reminded that if the uses of income in Table 33 do not accurately reflect actual mobilization for which the stockpile is to be used, neither of the two models will be in the right ballpark. Only the output and the

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<sup>1</sup>See Table 2 for the peacetime comparison.

Table 34. USES OF INCOME FOR A HYPOTHETICAL MOBILIZATION

Uses of Income	Year		
	1978	1979	1980
Gross National Product	1564.3	1750.6	1848.8
Personal Consumption	879.6	912.4	925.6
Durable Goods	163.4	173.3	173.0
Non-Durable Goods	358.7	365.2	369.3
Services	357.7	373.9	384.2
Gross Private Domestic Investment	207.1	219.9	215.3
Structures	72.9	70.1	70.0
Producers Durable Equipment	104.7	116.4	123.0
Inventory Change	30.6	34.7	23.7
Exports	117.7	121.6	116.4
Imports	-104.7	-119.7	-127.8
Government Purchases of Goods & Services	468.5	625.8	732.9
Public Construction	35.7	36.3	36.9
National Defense	172.8	321.1	421.2
Non-Defense Federal	54.2	54.2	54.2
State & Local Education	118.6	119.2	120.0

materials skirt differences are operating to distinguish the models.

## 2. Direct Projection of Titanium Usage

For a mobilization corresponding to that used for the FPA/ INFORUM comparison, we were able to obtain a list of associated material that might be produced to support the mobilization.

(These data were taken from worksheets provided by the military

Table 35. COMPARISON OF INFORUM AND FPA MODELS FOR MOBILIZATION

Material	Year 1 1978 INFORUM	Year 1 1978 FPA	Percent Difference	Year 2 1979 INFORUM	Year 2 1979 FPA	Percent Difference	Year 3 1980 INFORUM	Year 3 1980 FPA	Percent Difference
Antimony st	46,515.0	43,318.9	-6.1	52,870.8	47,505.8	-10.1	55,339.6	47,667.4	-13.9
Beryl st	17,238.0	18,331.8	-6.0	25,064.0	25,321.6	1.0	28,594.0	31,320.2	9.5
Bismuth th lbs	2,952.0	2,782.6	-5.7	3,575.4	3,191.7	-10.7	3,734.7	3,468.1	-7.1
Cadmium th lbs	19,580.0	21,690.8	-9.7	25,476.0	28,775.1	12.9	27,390.0	33,200.3	21.2
Feathers/Down th lbs	10,401.0	9,648.1	-7.2	11,364.0	10,422.4	-8.3	12,980.0	10,693.8	-17.5
Lead th st	2,048.0	2,107.0	-2.9	2,389.2	2,496.6	4.5	2,702.0	2,652.8	-1.8
Nickel st Contained	229,525.0	204,693.7	-10.8	289,460.0	242,184.8	-16.3	307,026.0	270,837.6	-11.8
Opium th lbs	515.0	561.0	9.0	554.0	581,811.7	5.0	555.0	594.0	7.1
Platinum th troy oz	1,073.0	750.5	-30.1	1,216.3	850.1	-30.1	1,277.8	900.6	-29.5
Quinine th avoir oz	3,739.0	2,091.9	-44.1	4,429.0	2,167.4	-51.1	4,807.0	2,213.6	-54.0
Rutile st	356,803.0	423,187.0	18.6	380,988.0	492,519.8	29.3	434,467.0	539,269.3	24.1
Silver th troy oz	196,142.0	208,569.4	6.3	231,863.0	237,636.1	2.5	232,853.0	253,341.3	8.8
Tantalum th lbs	3,716.0	2,828.1	-23.9	4,465.0	3,993.8	-10.6	6,461.0	5,050.6	-21.8
Titanium Sponge st	35,305.0	33,768.2	-4.3	51,578.0	53,705.4	4.1	68,126.0	76,959.8	13.0

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INSTITUTE FOR DEFENSE ANALYSES ARLINGTON VA PROGRAM --ETC F/G 15/5  
AN ASSESSMENT OF COMPUTATIONAL PROCEDURES TO DETERMINE REQUIREM--ETC(U)  
AUG 77 R W GILMER, P MCCOY

DAHC15-73-C-0200

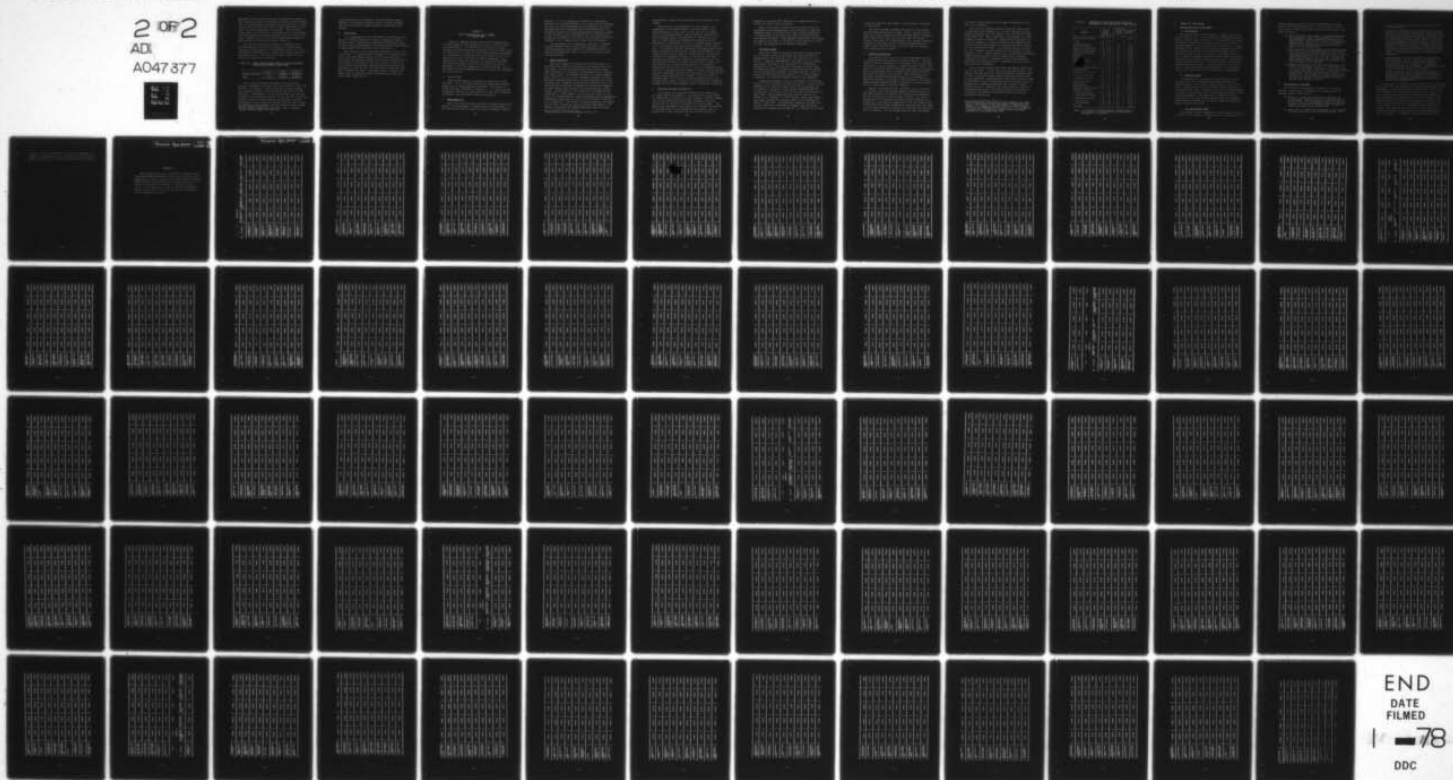
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departments showing their production requirements in wartime.) For titanium, we were also fortunate in having a detailed breakdown of titanium usage in military ships and aircraft.<sup>1</sup> Combining the two sources, we were able to obtain projections of the direct military requirements for titanium. From the input-output model, the new indirect requirements for titanium associated with military needs were estimated to be about 6,500 short tons. Summing these, the military and mobilization-generated requirements for titanium are shown in Table 35.

The FPA model was used to generate a comparable set of military/mobilization-oriented estimates of titanium usage. Using only military needs as a final demand vector, the direct and indirect requirements for titanium were computed using the input-output table. The results are shown in Table 36, and compared to the direct projections.

Table 36. DIRECT AND FPA PROJECTIONS OF MILITARY-ORIENTED TITANIUM REQUIREMENTS (SHORT-TONS)

	Year 1	Year 2	Year 3
Direct Estimate	11,111.1	28,056.6	36,406.2
FPA	17,927.3	24,044.2	28,982.4

Given the many problems associated with making these scenarios comparable--one starts with dollars and the other with materiel, the different timing of materiel purchases, spares and inventory problems, etc.--the results turn out to be quite comparable. FPA appears to be low for the first year (the one for which we are planning) and high for the last two. The direct estimates grow more slowly, however, and the total titanium requirements over the three year period differ by only 6.2 percent between the two methods. The FPA projection again appears

<sup>1</sup>Battelle Columbus Laboratories, *Current Status of the U.S. Titanium Industry*, MCIC-74-01 (March 1974), esp Sec XI.

percent between the two methods. The FPA projection again appears to be providing estimates within the right ballpark, and that are as good as those provided by other models and methods.

#### D. CONCLUSIONS

It is encouraging that the requirements for materials turn out to be broadly similar when they are computed in several different ways. Nonetheless, substantial differences in quantities *do* persist among models, and backcasting provides evidence of significant errors existing in the projections.

Three sources of error have been identified in the material projections: (1) wartime uses of income; (2) the output projections using input-output analysis; and (3) the skirt data. Among these, the greatest potential for error is probably due to our inability to closely tie the uses of income to the use of the stockpile; the material usage projections contribute substantially to error as well; the input-output projections probably contribute the least. Continued studies, research, and expert input on materials markets probably would reduce all these errors significantly.

## Chapter V

### FINAL CONSIDERATIONS AND A SUMMARY OF CONCLUSIONS

Chapter I suggested several broad criteria against which we should judge the methodology used by FPA to project stock-pile requirements: (1) the ability to account for a major increase in military spending and changes in other income flows; (2) the ability to account for direct and indirect requirements; (3) consideration of substitution possibilities; and (4) consideration of long- and short-run capacity problems. This chapter will discuss the treatment of substitution and short-run capacity problems by FPA, and then provide an overall assessment of the model against the criteria proposed. All of the conclusions and recommendations of the report are summarized in a final section.

#### A. SUBSTITUTION

Substitution should be considered in two places in the FPA model: (1) in the input-output table among broad industry groups; and (2) among individual materials. The effects of substitution were considered in Chapter I: it is almost always technically feasible, but high production costs may be entailed by having to use alternative production processes.

##### 1. Among Materials

This is the only place FPA explicitly considers substitution. Experts at the Department of Commerce and at the Department of the Interior are asked to review all uses of strategic critical

materials. If it is possible to substitute a non-critical material for a critical material, e.g., glass bottles for aluminum cans, the total requirements for the material are reduced. The guidelines for determining when and how substitution is allowed for purposes of reducing requirements generally conform to the criteria we have established; that is, substitution is assumed to be imposed if the cost of the alternative production technique is not "significantly" higher than the original.

This adjustment is not completely consistent. Although critical materials are not substituted directly for other critical materials, some indirect or intermediate effects of these substitutions will affect the pattern of usage of other critical materials.

## 2. Among Industries

The need to update the input-output table and keep it in conformity with modern technology has been stressed earlier in this report. We must also ask whether major shifts, among these industries, of technology or requirements may be induced by a mobilization. For example, shortages of casting capacity might result in the use of more forgings or stamping of metal; petroleum shortages might result in more industrial use of coal or natural gas. Among the economists with whom the use of this model has been discussed, the possibility of radical changes in the input-output table and the bill of goods has been a major concern. One authority on the economics of shortages has concluded that "...input-output...is not very well suited to the study of a wartime economy...rigid coefficients may be appropriate to peacetime conditions, but not in a nation ready to bear any cost to wage war."<sup>1</sup> The affect of such substitution is to affect both the bill of goods and the total output requirements. The material requirements are strongly dependent upon the output

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<sup>1</sup>Olson, *Economics of the Wartime Shortage*, op. cit, p. 141.

projection, of course, and are affected very directly by such changes.

Unfortunately, the adjustment for such changes is not independent of the events leading to the war itself. Will petroleum supplies be cut off? Or will the loss of foreign steel or electronics markets lead to extensive substitution of these processed goods? The difficulty of narrowing the scenario to useful limits has already been discussed, and the adjustment of coefficients or the bill of goods under a mobilization is essentially the same problem compounded several times over. The capacity shortages discussed below might provide some guide to aspects of this problem, and foreign dependence in key industrial sectors also might be a useful guide. And the very presence of an adequate stockpile of critical and strategic materials may prevent major industrial displacement, but great uncertainty will remain no matter how much study is made. Perhaps the best way to view this problem is as a substantial qualification of the results; just as there are tremendous uncertainties in choosing the right scenario to guide the mobilization, there are tremendous uncertainties associated with changes in the economic system induced by the scenario. Given our state of ignorance about such effects, the best assumption may be that no significant change is induced, but the uncertainty introduced through the use of this assumption must be explicitly recognized.

#### B. SHORT-RUN RESOURCE AVAILABILITY

If we divide the resources required by the economy into two types--labor and capital--it is possible that output might be constrained by shortages in either category. FPA has assumed that for *any* mobilization envisioned, sufficient labor and capital will be available to produce the required output. The input-output procedures themselves do not constrain the solution of required output so as to guarantee that adequate labor or capital are in fact available, and the solution may not be

feasible in the sense that there are not enough resources to produce the output levels projected.

Most of the results of this section are drawn from the Interindustry Forecasting Model of the University of Maryland (INFORUM), which, as we have seen, bears a broad resemblance to the FPA model; we have also seen that both models provide very similar forecasts. Since INFORUM contains both labor supply and capital stock data, it provides a source which can be used to check the assumption of no resource constraints.

### 1. The Labor Supply

Based upon trends in population and other relevant aspects of the workforce (such as retirement age and the number of working women), the 1978 labor force is projected to be 98.6 million. Using the INFORUM model, employment for each industry was forecast for each of 166 industries for a mobilization beginning in 1978. The projection was based on weekly hours of production, number of production and non-production workers, and on productivity estimates. The result was that output to sustain the mobilization would require 101.1 million workers; a shortfall of 2.5 million workers exists in the aggregate.

Unemployment probably could not be reduced to zero--three percent or so is probably the lower bound--due to such frictional problems as job turnover, worker skills and job openings not coinciding, or workers not being located geographically with job openings. The result is 5.5 million jobs not filled at any given time. The projected shortfall could be made up by a change in the composition of the workforce (more young workers, more women, raising the retirement age) or by increasing the number of work hours. The historical experience of women joining the workforce in World War II suggests that substantial shortfalls in manpower can be made up. An increase of two hours

of work per week from each member of the workforce could make up this deficit.

The labor shortage estimated here does not seem serious, but two qualifications are in order. First, specific skills might be in short supply and could hold down output; the aggregate figures quoted here could not take that into account. Second, later years of the mobilization (not currently directly relevant to FPA plans) result in labor shortages which are double those of the first year; for later years the problem could become much more severe.

## 2. Capacity Constraints

The immediate shift upward in output requirements imposed by a mobilization may exceed the available capacity. Over the course of the war, capacity can be expanded, but, for the first few months to a year, capacity is fixed at pre-war levels. The Bureau of the Census defines "practical capacity" as the greatest level of output which can be attained with current facilities and within a realistic work pattern. More work hours, more employees, and more shifts are allowed, but no expansion of plant and equipment is included in the definition. The Census Bureau annually measures actual utilization of plant and equipment as a percentage of practical capacity.

Because of varying economic conditions over the course of the business cycle, the possible capacity expansion will vary. The fourth quarters of 1973 and 1974 provide a good example of how the business cycle affects excess capacity. In 1973 the economy was at its peak and producing at rates estimated to be 84 percent of the practical capacity; by 1974 the situation was reversed with the economy operating at low rates near the trough of the recession and the utilization of practical capacity falling to 75 percent. We have chosen these two years to display

the range of excess capacity which might be available at the onset of an emergency.

The first two columns of Table 37 show the likely range of short-run excess capacity for a series of durable and non-durable producers; the "low" figure is for 1973 and the "high" prevailed in 1974. Both columns are excess capacity as a percentage of practical capacity. Column three of the table displays the expansion in output projected by the INFORUM model; it shows how much more capacity is required from each industry once the mobilization begins. The required capacity exceeds the "low" estimate in eight industries, and exceeds the "high" estimate in four. Large shortages occur in machinery (especially communications equipment) and in transportation equipment (especially aircraft). Shortages of capacity are generally associated with defense-intensive industries and the results seem intuitively reasonable.

These results indicate that output may indeed exceed capacity in some cases. In the short-run, policies may have to be imposed--civilian austerity, reduced government spending--which cut back on projected output levels beyond what had been previously considered. Experiments with alternative policies might be undertaken to shift the solution back to feasible levels, or mathematical programming techniques can be used to assure feasible results.<sup>1</sup> Certainly more effort should be devoted to determining the extent of the problem posed by the capacity constraints and whether it seriously affects the material requirement projections.

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<sup>1</sup>The programming format might maximize civilian consumption, for example, subject to constraints on military requirements, the labor supply, and capacity. For an example of this kind of model in a different context see M. Bruno, "A Programming Model for Israel," Ch. 12 in I. Adelman and E. Thorbecke (eds.), *The Theory and Design of Economic Development* (Baltimore, MD: Johns Hopkins Press, 1966).

Table 37. COMPARISON OF PRACTICAL SHORT-RUN OUTPUT EXPANSION TO THAT REQUIRED BY A MOBILIZATION

Industry Group	Possible Percent Outcome		Required Percent Output Expansion	Mobilization Shipments (Mil \$72)
	High	Low		
Food and Kindred Products	24	17	3.2	140,156
Meat	17	(NA)		
Tobacco Manufactures	21	20	10.7	11,474
Textile Mill Products	26	13	13.4	41,690
Apparel and Other Textiles	23	(NA)	11.0	35,291
Paper and Allied Products	21	12	11.9	36,136
Printing and Publishing	19	(NA)	9.9	38,104
Chemical	23	20	17.0	49,863
Coal and Oil	18	7	10.2	59,773
Petroleum Refining	14	(NA)	11.6	40,549
Rubber and Plastics	25	14	10.3	30,499
Plastics	30	(NA)	12.8	18,597
Leather and Leather Products	23	(NA)	20.0	7,324
Lumber and Wood	29	16	8.2	22,797
Sawmills, Planing Mills	26	(NA)	-9.3	6,932
Furniture and Fixtures	25	14	18.4	15,472
Household Furniture	25	(NA)	29.4	10,828
Stone, Clay, Glass	20	12	0.0	24,102
Primary Metal	16	9	10.2	79,395
Fabricated Metals	29	18	7.5	59,333
Machinery, Except Electrical	21	16	21.1	100,749
Electrical Machinery	30	18	35.2	92,782
Industrial Apparatus	24	(NA)	17.1	4,313
Communication Equipment	31	(NA)	60.1	25,242
Transportation Equipment	29	19	24.3	139,990
Motor Vehicles	25	(NA)	11.2	83,369
Aircraft & Parts	37	(NA)	66.3	35,774
Instruments	25	21	23.8	20,686

Source: U.S. Department of Commerce, Bureau of the Census, *Survey of Plant Capacity, 1974*, Current Industrial Reports MQCI(74)-1 (Washington, D.C.: GPO, 1976).

## C. SUMMARY OF CONCLUSIONS

### 1. Sources of Error in the Model

#### a. The Scenario

The war for which FPA is planning is vaguely understood and ill-defined, but is to bear a general resemblance to World War II. There is great difficulty in limiting the broad range of possible scenarios to any single scenario to be used for planning purposes. This difficulty has two effects: (1) great uncertainty must similarly be associated with any calculations derived from the initial set of assumptions drawn from an uncertain scenario; and (2) the state of ignorance about the future imparts a strongly conservative bias toward the planning assumptions as an effort is made to "play safe." The requirements for materials do seem to respond strongly to these basic assumptions in the scenario. The uncertainty in this initial part of the planning process probably leads to the greatest source of potential error in the calculation of requirements.

#### b. Materials Usage

An examination of the backcasts suggest that errors in projecting the use of individual materials by sector (the materials skirt) is the second largest source of error in the model. Improvements in this area might be best obtained by continued expert review of trends in the use of these materials. This would be especially useful for materials with small, highly specialized markets. The Department of Defense is often a large consumer of these specialized materials, and changes in weapon system technology and the use of specialized materials should be monitored closely.

#### c. The Input-Output Table

Backcasting revealed comparatively small errors in the projection of total output, averaging only 4 to 5 percent across

various industrial sectors. The FPA procedures are broadly correct and consistently applied. We do feel that the projections could be improved by keeping the data used by these procedures up-to-date.

- The input-output table needs to be updated regularly. A wide range of studies have indicated the need for such updating by either mechanical processes or by expert review. Expansion of the table to include non-ferrous metals (copper, zinc, etc.) is possible and should be done; the addition of other key sectors ought to be considered as well.
- The composition of final demand is derived from assumptions that are often untestable and by using comparatively old data. A detailed examination of the DoD requirements assumed by FPA reveal that they are particularly susceptible to such criticism. The age and uncertainty associated with these data, combined with the importance of DoD requirements in a mobilization, make a complete review important.
- Numerous comparisons were drawn throughout this study between FPA procedures and those of the INFORUM project at the University of Maryland. Both models draw on a common data base, and a closer liaison with INFORUM could provide FPA with continued data updates at a nominal cost. Both models use an input-output table and derive a bill of goods; continued comparisons of the data and forecasts could challenge both groups to improve their respective models.

## 2. The Adequacy of the Model

Four criteria were suggested in Chapter I to judge the adequacy of the model; the adequacy of the model is briefly measured against these criteria:

- (1) *Changes in Income Flows*--These are related to the scenario; the changes themselves are not known with any certainty. The computational procedures employed do seem to reflect the assumptions made with some consistency and material requirements react strongly to changes in these initial income flows.
- (2) *Computation of Intermediate Requirements*--Any problems here were discussed in the preceeding section. The

errors associated with the input-output analysis were encouragingly small.

- (3) *Substitution*--Substitution at the materials level is handled with reasonable consistency. Material requirements are reduced so no "substantial" cost penalties are induced by not having the material available. Substitution among industries is not really considered at all. The mobilization may induce changes in the bill of goods as shortages in raw materials not stockpiled (petroleum perhaps) or capacity shortages change technologies or purchasing patterns. Like the uncertainty tied to the scenario itself, these changes which might be induced by the scenario are not foreseeable in many cases. As another major source of uncertainty in the model, the potential effects of such changes must be recognized.

- (4) *Capacity*--Major construction efforts to support the war effort have not been adequately incorporated into the FPA model. Drawing on historical patterns of civilian investment, FPA neglected the extensive experience of the U.S. Government in undertaking quasi-private investment during wartime. Adjustment for such a building program should be undertaken.

Short-run capacity (before major expansion efforts become effective) may be an effective constraint on production in the initial stages of the mobilization. Our scenario revealed constraints on several key industries--communications equipment, aircraft, and perhaps some primary metals.

The FPA model is adequate given the qualifications expressed above and if the user recognizes the remaining weaknesses of the methodology. But supposing these qualifications are put aside for the moment and the best methods and data are brought to bear, the user must recognize that substantial uncertainty is still associated with the scenario and with any technological changes directly or indirectly induced by the scenario. And even if these uncertainties are eliminated (as they were in our backcasts), errors of a significant magnitude may still persist. The model is short of perfect, and it will require close and continued monitoring of the data and assumptions to keep it reasonable. Continued review of both the data and

results by FPA, the Department of Defense, the Department of Commerce, the Department of the Interior, and other interested agencies is critical to obtaining the best possible estimates.

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#### APPENDIX A

This appendix is the table described in Chapter II which transforms Defense expenditures into a bill of goods for the Department of Defense. The top of the table shows the Defense Budget broken in 25 categories; each column allocates a proportion of this part of the budget to each input-output sector. Each column sums to one; the product of expenditure levels in each part of the budget and the row coefficients sum to expenditure by sector.

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**DEFENSE DITY**

MUM	I-O SECTOR	MILITARY PERSONNEL	OPERATIONS AND MAINTENANCE - 9722	RESEARCH AND DEVELOPMENT - 9723	FAMILY HOUSING - 9724	MILITARY CONSTRUCTION - 9725
		EL - 97221	22			
	LIVESTOCK/LIVESTOCK PRODUCTS	0.000000	0.00028	0.000000	0.000000	0.000000
	OTHER AGRICULTURAL PRODUCTS	0.000000	0.000008	0.000000	0.000000	0.000000
	FORESTRY/FISHERY PRODUCTS	0.000000	0.000000	0.000000	0.000000	0.000000
	AGRICULTURAL/FORESTRY/FISHERY SERVICES	0.000000	0.001267	0.000000	0.000000	0.000000
	IRON/FERROUS METAL ORES MINING	0.000000	0.000000	0.000000	0.000000	0.000000
	NONFERROUS METAL ORES MINING	0.000000	0.000000	0.000000	0.000000	0.000000
	COAL MINING	0.000000	0.001365	0.000000	0.000000	0.000000
	CRUDE PETROLEUM/NATURAL GAS	0.000000	0.000000	0.000093	0.000000	0.000000

9	STONE/CLAY MINING	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	CHEMICAL/FERTILIZER MINING	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
11	INDUSTRIAL CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	OFFICE BLDGS/HOME CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	STORES AND GARAGE CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	RELIGIOUS CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	EDUCATIONAL CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	HOSPITALS AND INSTITUTIONS CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	SOCIAL AND RECREATIONAL CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	MISC. EXC. FARM/PUBLIC CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

FARM (NON-RESIDENTIAL)									
19	TOTAL CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TELEPHONE AND TELEGRAPH CONSTRUCTION									
20	TELEPHONE AND TELEGRAPH CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
RAILROAD CONSTRUCTION									
21	RAILROAD CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GAS AND PETROLEUM UTILITY CONSTRUCTION									
22	GAS AND PETROLEUM UTILITY CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ELECTRICITY AND POWER UTILITY CONSTRUCTION									
23	ELECTRICITY AND POWER UTILITY CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
OTHER PUBLIC UTILITY CONSTRUCTION									
24	OTHER PUBLIC UTILITY CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
OIL AND GAS DRILLING CONSTRUCTION									
25	OIL AND GAS DRILLING CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ALL OTHER PRIVATE CONSTRUCTION									
26	ALL OTHER PRIVATE CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FARM RESIDENTIAL CONSTRUCTION									
27	FARM RESIDENTIAL CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NON-FARM RESIDENTIAL CONSTRUCTION									
28	NON-FARM RESIDENTIAL CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TOTAL CONSTRUCTION									
	TOTAL CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

29	HIGHWAY CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
30	MILITARY FACILITIES CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	.687124
31	ALL OTHER PUBLIC CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	.250547	.072977
32	MAINTENANCE/REPAIR CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	.380037	.074482
33	ORDNANCE/ACCESSORIES	0.000000	0.000000	0.000000	.204100	0.000000	0.000000
34	FOOD/KINDRED PMU	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
35	TOBACCO MANUFACTURE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
36	BROAD/NARROW FAN RIGS/STAMP/THREAD MILLS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
37	MISCELLANEOUS IN TEXTILE GOODS/PLANT & EQUIPMENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
38	APPAREL	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000





59	METAL CONTAINERS	0.00000	0.01279	0.00001	0.00000	0.00000
60	HEATING, PLUMBING /STRUCTURAL METAL L PRODUCTS	0.00000	0.00506	0.00292	0.00000	0.00000
61	STAMPINGS, SCREEN /MACHINE PRODUCTS /BOLTS	0.00000	0.00379	0.00236	0.00000	0.00000
62	OTHER FABRICATED METAL PRODUCTS	0.00000	0.00042	0.00477	0.00000	0.00000
63	ENGINES/TURBINES	0.00000	0.00000	0.00616	0.00000	0.00000
64	FARM MACHINERY/E QUIPMENT	0.00000	0.00000	0.01426	0.00000	0.00000
65	CONSTRUCTION, MIN ING/OIL FIELD MA CHINERY	0.00000	0.00000	0.01111	0.00000	0.00000
66	MATERIALS HANDLI NG MACHINERY/EQU PMENT	0.00000	0.00000	0.00350	0.00000	0.00000
67	METALWORKING MAL MACHINERY/EQUIPMENT	0.00000	0.004102	0.01575	0.00000	0.00000
68	SPECIAL INDUSTRY MACHINERY/EQUIP MENT	0.00000	0.00000	0.00544	0.00000	0.00000

GENERAL INDUSTRIAL	0.000000	0.003720	0.01516	0.000000	0.000000
69 AL MACHINERY/EQUIPMENT					
MACHINE SHOP PHU	0.000000	0.000000	0.00269	0.000000	0.000000
70 DUCTS					
OFFICE/COMPUTING	0.000000	0.00522	0.03092	0.000000	0.000000
71 /ACCOUNTING MACHINES					
SERVICE INDUSTRIAL	0.000000	0.02823	0.01154	0.000000	0.000000
72 MACHINES					
ELECTRIC INDUSTRIAL	0.000000	0.00805	0.02899	0.000000	0.000000
73 LAL EQUIPMENT/APPARATUS					
HOUSEHOLD APPLIANCES	0.000000	0.01549	0.028286	0.000000	0.000000
74 NCES					
ELECTRIC LIGHTING	0.000000	0.00436	0.10944	0.000000	0.000000
75 WIRING EQUIPMENT					
RADIO, TELEVISION /COMMUNICATION EQUIPMENT	0.000000	0.00013	0.103181	0.000000	0.000000
76					
ELECTRONIC COMPUTERS	0.000000	0.01575	0.024024	0.000000	0.000000
77					
MISC. ELECTRICAL MACHINERY/EQUIPMENT/SUPPLIES	0.000000	0.00799	0.03518	0.000000	0.000000
78					

MOION VEHICLES/	0.000000	0.012161	0.031205	0.000000	0.000000
79 EQUIPMENT	0.000000	0.012161	0.031205	0.000000	0.000000
AIRCRAFT/PARTS	0.000000	0.025323	0.026640	0.000000	0.000000
80	0.000000	0.025323	0.026640	0.000000	0.000000
OTHER TRANSPORTATION EQUIPMENT	0.000000	0.003011	0.003503	0.000000	0.000000
81	0.000000	0.003011	0.003503	0.000000	0.000000
SCIENTIFIC/COMMUNICATIONS	0.000000	0.001482	0.019273	0.000000	0.000000
82 COLLING INSTRUMENTS	0.000000	0.001482	0.019273	0.000000	0.000000
OPTICAL/OPHTHALMIC/PHOTOGRAPHIC EQUIPMENT	0.000000	0.000103	0.005120	0.000000	0.000000
83	0.000000	0.000103	0.005120	0.000000	0.000000
MISCELLANEOUS MANUFACTURING	0.000000	0.001329	0.000741	0.000000	0.000000
84	0.000000	0.001329	0.000741	0.000000	0.000000
TRANSPORTATION/WAREHOUSING	0.050953	0.021100	0.000000	0.001755	0.001328
85	0.050953	0.021100	0.000000	0.001755	0.001328
COMMUNICATIONS-ELECTRONIC/RADIO/TV BRUAS PRACTING	0.000000	0.009909	0.000000	0.000000	0.000000
86	0.000000	0.009909	0.000000	0.000000	0.000000
RADIO/TV BROADCASTING	0.000000	0.000000	0.000000	0.000000	0.000000
87	0.000000	0.000000	0.000000	0.000000	0.000000
ELECTRIC/GAS/WATER/SANITARY SERVICES	0.000000	0.005105	0.000000	0.000000	0.000000
88	0.000000	0.005105	0.000000	0.000000	0.000000

90 WHOLESALE/RETAIL	0.000000	0.017937	0.000000	0.000000	0.000000	0.000000	0.000000
91 TRADE	0.000000	0.017937	0.000000	0.000000	0.000000	0.000000	0.000000
92 FINANCE/INSURANCE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
93 REAL ESTATE/RENT	0.000000	0.037553	0.000000	0.000000	0.000000	0.000000	0.000000
94 AL	0.000000	0.037553	0.000000	0.000000	0.000000	0.000000	0.000000
95 HOTELS/PERSONAL/	0.000000	0.017004	0.000000	0.000000	0.000000	0.000000	0.000000
96 REPAIR SERVICES	0.000000	0.017004	0.000000	0.000000	0.000000	0.000000	0.000000
97 INC. AUTO	0.000000	0.017004	0.000000	0.000000	0.000000	0.000000	0.000000
98 BUSINESS SERVICE	0.000000	0.019702	0.000000	0.000000	0.000000	0.000000	0.000000
99 RESEARCH/DEVELOP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
100 MENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
101 AUTOMOBILE REPAIR	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
102 R/SERVICE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
103 AMUSEMENTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
104 MEDICAL/EDUCATION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
105 MEDICAL SVCS/NONPRO	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
106 FEDERAL GOVERNMENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
107 ENTERPRISES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

STATE/LOCAL GOV	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
99 AMMNT ENTERPRI						0.00000
100 IMPORTS	0.25000	0.12534	0.00000	0.00000	0.00000	0.00000
BUS TRAVEL ENTEN	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
101 TAINMENT/GIFTS						
OFFICE SUPPLIES	0.00000	0.00276	0.00000	0.00000	0.00000	0.00000
102						
SCRAP USED/SECUN	0.00000	0.11083	0.00000	0.00000	0.00000	0.00000
103 DMANG GOODS						
FED. GOVT. NONMIL	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
104 FENSE COMP						
FED. GOVT. DEFEN	0.00121	0.17314	0.10000	0.027747	0.074170	
105 SE NONMILITARY						
FED. GOVT. DEFEN	0.11031	0.049066	0.00000	0.00000	0.00000	0.00000
106 SE MILITARY COMP						
STATE/LOCAL GOV	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
107 AMMNT COMPENSAT						
REST OF THE WORLD	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
108 D INDUSTRY						

HOUSEHOLD INDUSTRY	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
109 RV						0.000000
TOTAL	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
DEFENSE DITI						
NUM I-Q SECTOR	CIVIL DEFENSE -	AIRCRAFT - 97331	ARMY MISSILES -	NAVY MISSILES -	AIR FORCE MISSIL	
	97229		97341	97342	ES - 97343	
LIVESTOCK/LIVEST						
1 OCK PRODUCTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
OTHER AGRICULTUM						
2 AL PRODUCTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FORESTRY/FISHERY						
3 PRODUCTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
AGRICULTURAL/FUM						
4 STRY/FISHERY DE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
BUICES						
IRON/FERROALLOY						
5 ONES MINING	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NONFERROUS METAL						
6 ONES MINING	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
COAL MINING						
7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000



MISC. EXC. FARM/	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19 PUBLIC CONSTRUCT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19 FARM (NON-RESIDENTIAL)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20 TELEPHONE AND TELEGRAPH CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21 RAILROAD CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22 GAS AND PETROLEUM UTILITY CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23 ELECTRIC AND POWER UTILITY CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
24 OTHER PUBLIC UTILITY CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
25 OIL AND GAS DRILLING CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
26 ALL OTHER PRIVATE (EXC. FARM) CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
27 FARM RESIDENTIAL CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

NON-FARM RESIDEN	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28 TIAL CONSTRUCTIO	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
HIGHWAY CONSTRUCT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
29 TION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MILITARY FACILIT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
30 IES CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ALL OTHER PUBLIC	0.007730	0.00000	0.00000	0.00000	0.00000	0.00000
31 CONSTRUCTION	0.007730	0.00000	0.00000	0.00000	0.00000	0.00000
MAINTENANCE/REPA	0.004741	0.00000	0.00000	0.00000	0.00000	0.00000
32 IR CONSTRUCTION	0.004741	0.00000	0.00000	0.00000	0.00000	0.00000
ORDNANCE/ACCESB	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
33 RIES	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
FOOD/RINDRED PHU	0.108799	0.00000	0.00000	0.00000	0.00000	0.00000
34 DUCTS	0.108799	0.00000	0.00000	0.00000	0.00000	0.00000
TOBACCO MANUFACT	0.002727	0.00000	0.00000	0.00000	0.00000	0.00000
35 UNES	0.002727	0.00000	0.00000	0.00000	0.00000	0.00000
BROAD/NARROW FAR	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
36 RICS-YARN/THREAU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MILLS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MISCELLANEOUS IL	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
37 XTILE GOONS/PLUO	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
R COVERING	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

38	APPAREL	0.022700	0.000000	0.000000	0.000000	0.000000	0.000000
39	MISCELLANEOUS PA BRICATED TEXTILE PRODUCTS	0.014803	0.000000	0.000000	0.000000	0.000000	0.000000
40	LUMBER/HOOD BRUW DUCTS/EXCEPT COMIT ALINGS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
41	WOODEN CONTAINER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
42	HOUSEHOLD FURNIT URE	0.031126	0.000000	0.000000	0.000000	0.000000	0.000000
43	OTHER FURNITURE/ FIXTURES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
44	PAPER/ALLIED PRU DUCTS/EXCEPT CUN TAINERS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
45	PAPERBOARD CONIA INERS/BOXES	0.015991	0.000000	0.000000	0.000000	0.000000	0.000000
46	PRINTING/PUBLISM ING	0.007107	0.000000	0.000000	0.000000	0.000000	0.000000
47	CHEMICALS/SELECT ED CHEMICAL PRUD UCTS	0.016675	0.000000	0.000000	0.019650	0.013030	0.009410









90	ELECTRIC/GAS/HAIR	0.009632	0.000000	0.000000	0.000000	0.000000	0.011369
91	EP/SANITARY SERV						
92	WHOLESALE/RETAIL	0.031110	0.010126	0.015070	0.000000	0.000000	0.000000
93	TRADE						
94	FINANCE/INSURANCE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
95	REAL ESTATE/RENT	0.009577	0.000000	0.000000	0.000000	0.000000	0.000000
96	HOTELS/PERSONAL/	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
97	REPAIR SERVICES,						
98	EXC.AUTO						
99	BUSINESS SERVICE	0.141702	0.010217	0.000000	0.000000	0.000000	0.000000
100	RESEARCH/DEVELOP	0.139105	0.000000	0.000000	0.000000	0.000000	0.000000
101	MENT						
102	AUTOMOBILE REPAIR	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
103	W/SERVICE						
104	AMUSEMENTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
105	MEDICAL/EDUCATION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
106	NAL SVCS./NONPMU						
107	PTV PER						



[illegible]





ALL OTH PRIVATE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
26 EXC FARMS) CONSTRUCTION									
FARM RESIDENTIAL	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
27 CONSTRUCTION									
NON-FARM RESIDENTIAL	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28 TOTAL CONSTRUCTION									
HIGHWAY CONSTRUCTION	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
29 TION									
MILITARY FACILITIES	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
30 CONSTRUCTION									
ALL OTHER PUBLIC	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
31 CONSTRUCTION									
MAINTENANCE/REPAIR	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
32 IR CONSTRUCTION									
ORDNANCE/ACCESSORIES	504741	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
33 RIES									
FOOD/KINDRED PRODUCTS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
34 DUCTS									
TOBACCO MANUFACTURING	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
35 UNES									







66	MATERIALS HANDLING	0.33701	0.023605	0.000000	0.000000	0.000000	0.000000
67	METALWORKING MACHINERY/EQUIPMENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
68	SPECIAL INDUSTRY MACHINERY/EQUIPMENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
69	GENERAL INDUSTRIAL MACHINERY/EQUIPMENT	0.000000	0.012360	0.081669	0.000000	0.000000	0.000000
70	MACHINE SHOP PHU DUCTS	0.000000	0.013332	0.028792	0.000000	0.000000	0.000000
71	OFFICE/COMPUTING /ACCOUNTING MACHINES	0.000000	0.001051	0.000000	0.000000	0.12612	0.029062
72	SERVICE INDUSTRY MACHINES	0.000000	0.000755	0.000000	0.000000	0.000000	0.000000
73	ELECTRIC INDUSTRIAL EQUIPMENT/APPARATUS	0.000000	0.010776	0.000000	0.000000	0.047017	0.016023
74	HOUSEHOLD APPLIANCES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
75	ELECTRIC LIGHTING EQUIPMENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000





AMUSEMENTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
96	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
MEDICAL EDUCATION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
97	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NAL SVCS./NONPHU ATTY GEN	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FEDERAL GOVERNMENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
98	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NT ENTERPRISES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
STATE/LOCAL GOVERNMENT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
99	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
MENT ENTERPRISES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
IMPORTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
100	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
BUS TRAVEL ENTLEM	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
101	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TAINMENT/GIFTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
OFFICE SUPPLIES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
102	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SCRAP USED/SECUR	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
103	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
DMAMU GOODS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FED. GOVT. NONPHU	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
104	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FENSE COMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FED. GOVT. DEFEN	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
105	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE NONMILITARY C	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
OMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

.....									
FED. GOVT. DEFEN	.	.	.	.	.	.	.	.	.
106 SE MILITARY COMP	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
.....									
STATE/LOCAL GOVE	.	.	.	.	.	.	.	.	.
107 PAYMENT COMPENSAT	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
ION	.	.	.	.	.	.	.	.	.
.....									
REST OF THE NOKL	.	.	.	.	.	.	.	.	.
108 INDUSTRY	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
.....									
HOUSEHOLD INDUST	.	.	.	.	.	.	.	.	.
109 RY	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
.....									
TOTAL	.	1.000000	.	1.000000	.	1.000000	.	1.000000	1.000000
.....									
DEFENSE DITY									
.....									
NUM 1-0 SECTOR	.	.	.	.	.	.	.	.	.
	.	AIM FORCE ELECTN	.	MARINE CORPS ELE	.	ARMY AMMUNITION	.	NAVY AMMUNITION	.
	.	ONICS/COMMUNICAT	.	CTRONICS/COMMUNI	.	- 97371	.	- 97372	.
	.	IONS - 97382	.	CATIONS - 97364	.		.		.
.....									
LIVESTOCK/LIVEST	.	.	.	.	.	.	.	.	.
1 OCK PRODUCTS	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
.....									
OTHER AGRICULTUM	.	.	.	.	.	.	.	.	.
2 AL PRODUCTS	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
.....									
FORESTRY/FISHERY	.	.	.	.	.	.	.	.	.
3 PRODUCTS	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
.....									
AGRICULTURAL/FUN	.	.	.	.	.	.	.	.	.
4 ESTRY/FISHERY SE	.	0.000000	.	0.000000	.	0.000000	.	0.000000	0.000000
SERVICES	.	.	.	.	.	.	.	.	.
.....									







35	TOBACCO MANUFACT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
36	BROAD/NARROW FAB	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
37	MISCELLANEOUS 12	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
38	APPAREL	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
39	MISCELLANEOUS PA	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
40	LUMBER/WOOD PROD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
41	WOODEN CONTAINER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
42	HOUSEHOLD FURNIT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
43	OTHER FURNITURE/	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
44	PAPER/ALLIED PRO	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

45	PAPERBOARD CONIA INERS/BONES	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
46	PRINTING/PUBLISH ING	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
47	CHEMICALS/SELECT ED CHEMICAL PROD UCTS	0.00000	0.00000	0.00000	0.00000	0.078195	0.011349	0.00000	0.074074
48	PLASTICS/SYNTHET IC MATERIALS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
49	DRUGS/CLEANING/IT EMS PREPARATIO NS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
50	PAINTS/ALLIED PH ODUCTS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
51	PETROLEUM REFINI NG/RELATED INDUS TRIES	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.008367
52	RUBBER/MISCELLAN EOUS PLASTICS PH ODUCTS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
53	LEATHER TANNING/ INDUSTRIAL LEATH ER PRODUCTS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
54	FOOTWEAR/OTHER L EATHER PRODUCTS	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000





ELECTRIC LIGHTING	0.000000	0.000000	0.000000	0.000000	0.000000
75 MINING EQUIPMENT					0.000000
RADIO, TELEVISION					
76 COMMUNICATIONS EQUIPMENT	.770154	.260717	0.000000	.175434	.009310
ELECTRONIC COMPUTERS					
77 ACCESSORIES	.045360	.154427	0.000000	0.000000	0.000000
MISC. ELECTRICAL					
78 MACHINERY/EQUIPMENT/SUPPLIES	0.000000	0.000000	0.000000	0.000000	0.000000
MOTOR VEHICLES/VEHICLE EQUIPMENT					
79 EQUIPMENT	0.000000	0.000000	0.000000	.025599	0.000000
AIRCRAFT/PARTS					
80	0.000000	0.000000	0.000000	.031181	.009408
OTHER TRANSPORTATION EQUIPMENT					
81	0.000000	0.000000	0.000000	0.000000	0.000000
SCIENTIFIC/COMMUNICATIONS EQUIPMENT					
82	0.000000	0.000000	0.000000	.024723	0.000000
OPTICAL, OPHTHALMIC/PHOTOGRAPHIC EQUIPMENT					
83	.001705	0.000000	0.000000	.018598	0.000000
MISCELLANEOUS MANUFACTURING					
84	0.000000	0.000000	0.000000	.003141	0.000000

TRANSPORTATION	0.021042	0.017958	0.006039	0.013717	0.009125
85 AREHOUSING					
COMMUNICATIONS					
86 XC-RADIO/TV BRUA	0.000000	0.000000	0.000000	0.000000	0.000000
ncActing					
RADIO/TV BROADLA					
87 STING	0.000000	0.000000	0.000000	0.000000	0.000000
ELECTRIC/GAS/HAT					
88 ER/SANITARY SEMV	0.000000	0.000000	0.000000	0.000000	0.000000
ICES					
WHOLESALE/RETAIL					
89 TRADE	0.024414	0.159129	0.002592	0.034526	0.010502
FINANCE/INSURANC					
90 E	0.000000	0.000000	0.000000	0.000000	0.000000
REAL ESTATE/RENT					
91 AL	0.000000	0.000000	0.000000	0.000000	0.000000
HOTELS/PERSONAL/					
92 REPAIR SERVICES,	0.000000	0.000000	0.000000	0.000000	0.000000
PIC,AUTO					
BUSINESS SERVICE					
93 S	0.000000	0.000000	0.000000	0.000000	0.000000
RESEARCH/DEVELOP					
94 MENT	0.000000	0.000000	0.000000	0.000000	0.000000

AUTOMOBILE REPAIR									
95	R/SERVICE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
AMUSEMENTS									
96		0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
MEDICAL+EDUCATION									
97	NAL SVCS./NONPMU	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FEDERAL GOVERNMENT ENTERPRISES									
98	NT ENTERPRISES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
STATE/LOCAL GOVERNMENT ENTERPRISES									
99	STATE/LOCAL GOVERNMENT ENTERPRISES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
IMPORTS									
100	IMPORTS	0.052697	0.166220	0.048001	0.019567	0.000000	0.000000	0.000000	0.000000
BUS TRAVEL ENTERTAINMENT/GIFTS									
101	BUS TRAVEL ENTERTAINMENT/GIFTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
OFFICE SUPPLIES									
102	OFFICE SUPPLIES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SCRAP USED/SECURITY									
103	SCRAP USED/SECURITY	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FED. GOVT. NONRECURRING EXPENSE COMP									
104	FED. GOVT. NONRECURRING EXPENSE COMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

[illegible]



















RESEARCH/DEVELOP	0.000000	0.000000	0.000000	0.000000	0.000000
94 MENT					0.000000
AUTOMOBILE REPAIR	0.000000	0.000000	0.000000	0.000000	0.000000
95 R/SERVICE					
AMUSEMENTS	0.000000	0.000000	0.000000	0.000000	0.000000
96					
MEDICAL EDUCATION	0.000000	0.000000	0.000000	0.000000	0.000000
97 NAL SVCS./NONPMU					
98 NT ENTERPRISES	0.000000	0.000000	0.000000	0.000000	0.000000
STATE/LOCAL GOVERNMENT ENTERPRISES	0.000000	0.000000	0.000000	0.000000	0.000000
100 IMPORTS	0.000000	0.000000	0.000000	0.000000	0.000000
BUS TRAVEL ENTERTAINMENT/GIFTS	0.000000	0.000000	0.000000	0.000000	0.000000
101					
OFFICE SUPPLIES	0.000000	0.000000	0.000000	0.000000	0.000000
102					
SCRAP USED/SECURED	0.000000	0.000000	0.000000	0.000000	0.000000
103					

[illegible]



OFFICE BLDGS/WH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
12 HOUSE CONSTRUCTION							
STORES AND GARAGE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
13 ES CONSTRUCTION							
RELIGIOUS CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
14 UCTION							
EDUCATIONAL CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
15 TRUCION							
HOSPITALS AND IN	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
16 STITUTIONS CONSTRUCTION							
SOCIAL AND RECREATION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
17 ATIONAL CONSTRUCTION							
MISC. (E.C. FARM/H	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
18 UBLIC) CONSTRUCTION							
FARM (NON-RESIDENTIAL) CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
19 TIAL) CONSTRUCTION							
TELEPHONE AND TELEGRAPH CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20 LEGRAPH CONSTRUCTION							
RAILROAD CONSTRUCTION	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21 CTION							

















102 OFFICE SUPPLIES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SCRAP USEN/SECUR	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
103DHAND GOODS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FED. GOVT. NONWE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
104FENSE COMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FED. GOVT. REFEN	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
105SE NUMILITARY C	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
OMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FED. GOVT. REFEN	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
106SE MILITARY COMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
STATE/LOCAL GOVT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
107RMENT COMPENSAI	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TON	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
BEST OF THE NOME	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1080 INDUSTRY	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
HOUSEHOLD INDUST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
INDRY	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TOTAL	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000